PB-240 053

RADIOLOGICAL HEALTH DATA. VOLUME 6, NUMBERS 10-12, OCTOBER-DECEMBER 1965

Public Health Service
Washington, D. C.

December 1965

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BIBLIOGRAPHIC DATA SHEET

1. Report No. RHD 6 (10-12)

2.

PB 240 053

4. Title and Subtitle
Radiological Health Data
Volume 6, Nos 10-12

5. Report Date Oct-Dec 1965

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Oct-Dec 1965

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented. in 23 volumes. For prices of individual issues, see below:

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

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PRICES SUBJECT TO CHANGE

17c. COSATI Field/Group

18. Availability Statement
Release unlimited

1

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page UNCLASSIFIED

21. No. of Pages 211

22. Price PC/MF 7.25/2.25

RADIOLOGICAL HEALTH DATA

VOLUME 6, NUMBER 10
OCTOBER 1965

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

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Synopses of contributed articles are presented below in reference card format for the reader's convenience.

RADIOACTIVITY SURVEY OF THE LOWER COLUMBIA RIVER IN OREGON, AUGUST 1963—JULY 1964. *Toombs, G. L.* (Oregon State Board of Health). *Radiological Health Data, Vol. 6, September 1965*, pp. 567–572.

Fission product and neutron-activation radionuclides were investigated in environmental samples collected from the lower Columbia River and the Oregon seacoast during the period August 1963 through July 1964. Concentrations of chromium–51, zinc–65, potassium–40, zirconium–95—niobium–95, and ruthenium 103+106, in samples of water, sediment, algae, intertidal organisms (mussels, snails, sea anemones) and edible shellfish (crabs, oysters) are presented in tabular and graphical form, summarized, and discussed. The radionuclide most commonly found in the samples analysed was zinc–65, with significant concentrations observed in all edible shellfish samples. Fission product radionuclides zirconium–95—niobium–95 and ruthenium 103+106 showed a steady decrease over this period, probably as a result of decreased atmospheric fallout, following the atmospheric test ban treaty.

IODINE–131 IN BOVINE THYROIDS, OCTOBER-DECEMBER 1964. *E. J. Baratta, E. R. Williams* (Division of Radiological Health, PHS), and *G. Murray* (Agricultural Research Division, USDA). *Radiological Health Data, Vol. 6, October 1965*, pp. 573–578.

Bovine thyroid specimens from 17 collection areas were analyzed for iodine–131 content during the period October–December 1964. The thyroid results for Colorado, Georgia, New York, and Mississippi, compared with milk and air levels of iodine–131 from the same areas, indicated that collection and analysis of bovine thyroids is an extremely sensitive method for the detection of intrusions of iodine–131 into the environment.

STRONTIUM–90 IN HUMAN VERTEBRAE, 1964 RESULTS. *J. Rivera* (Health and Safety Laboratory, AEC). *Radiological Health Data, Vol. 6, October 1965*, pp. 579–581.

As part of a program started in 1961, specimens of human vertebrae from New York, Chicago, and San Francisco were analyzed for strontium–90 content and the results compared to estimates of these levels predicted from diet study data for the same locations. Agreement between calculated and observed strontium–90/calcium ratios supports both the validity of bone sampling and the accuracy of the diet study estimates.

PROJECTED VALUES OF CESIUM–137 BODY BURDENS IN ANAKTUVUK PASS ESKIMOS FOR THE SUMMER OF 1965, BASED ON FINDINGS IN CARIBOU MUSCLE. *J. R. Coleman* (Division of Radiological Health, PHS). *Radiological Health Data, Vol. 6, October 1965*, pp. 582–586.

A method of predicting body burdens of cesium–137 in Anaktuvuk Pass Eskimos is developed, using whole body counting data for a control group of local Eskimos and cesium–137 levels in caribou flesh. The model yields reasonably accurate approximations to the observed data. It is concluded that expected body burdens will be lower in July 1965 than those observed in July–August 1964, and an average body burden of approximately 0.9 μCi is estimated for the summer of 1965.

COMPARISON OF CESIUM–137 BINDING CHARACTERISTICS IN PANGOLA HAY AND SPANISH MOSS. *R. L. Elder* and *W. Moore, Jr.* (Division of Radiological Health, PHS). *Radiological Health Data, Vol. 6, October 1965*, pp. 590–593.

Preliminary studies comparing Pangola hay and Spanish moss indicate that most of the cesium–137 of Pangola hay is a lightly-bound surface contaminant and may be removed by water washing, but the plant structure of Spanish moss tightly binds all of the detectable nuclides. It was demonstrated that when cell structure of either plant was damaged by grinding, it acted as a simple ion exchange system.

Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network
June 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about five hours after the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators report (by telephone) field estimates greater than 10 pCi/m^3 (except for Hawaii, Alaska, and Puerto Rico, which report 5 pCi/m^3) to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Field estimates and laboratory measurements of daily concentrations and the estimated ages for selected samples are reported in the monthly RSN report (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Sampling

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1,800 cubic meters of air are drawn through a filter during the 24-hour sampling period. The filters are forwarded to the RSN laboratory in Rockville, Maryland, where the gross beta activity is measured 4 days after the sampling period and again 7 days later if the net count rate is 2,000 cpm or higher. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated and the activity at time of collection determined.[1]

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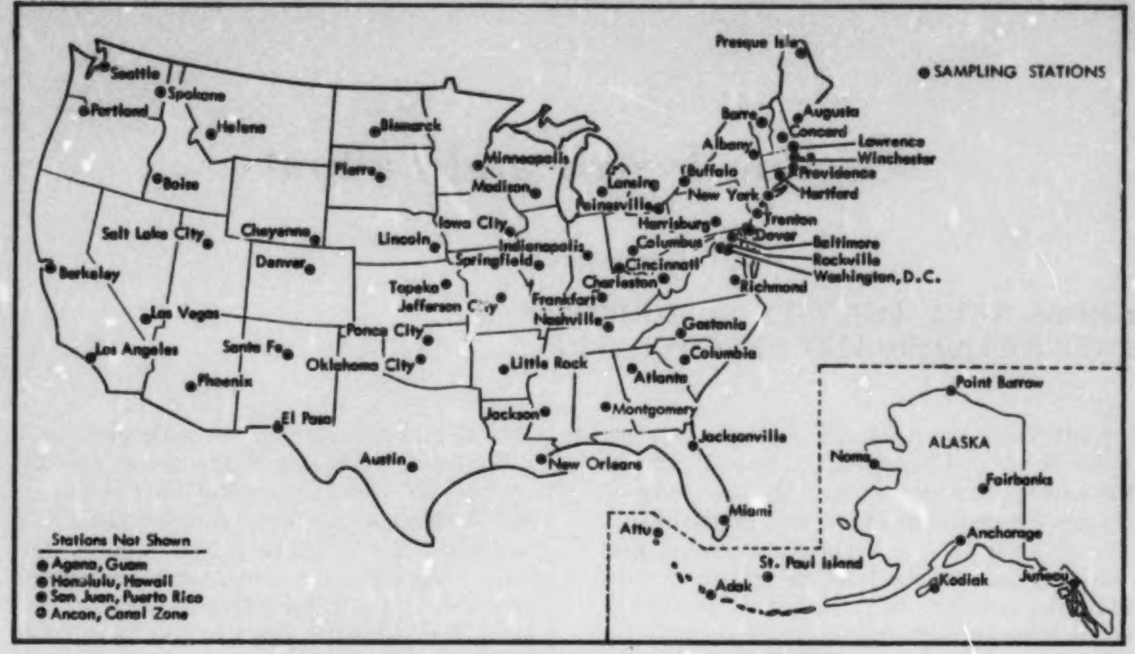
[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.


Presque Isle
● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Bismarck
Minneapolis
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
New York
Lansing
Painesville
Madison
Pierre
Boise
Iowa City
Lincoln
Salt Lake City
Cheyenne
Harrisburg
Trenton
Dover
Columbus
Baltimore
Rockville
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Indianapolis
Springfield
Cincinnati
Denver
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Richmond
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Nashville
Las Vegas
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Ponca City
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Phoenix
Point Barrow
ALASKA
Montgomery
Jackson
El Paso
Jacksonville
Nome
Austin
New Orleans
Fairbanks
Miami
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling locations

The total precipitation is sampled continuously at most RSN stations on a daily basis, using funnels with collection areas of 0.4 square meter. If the rainfall exceeds 0.02 inch, the precipitation sample is analyzed for gross beta activity (*1*). Additionally, analyses for specific radionuclides may be performed.

In the laboratory, the gross beta activity in evaporated precipitation samples is calculated by the same method used for analyzing the air filters. Total deposition for the sample is calculated by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nCi/m², C is the concentration in pCi/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month.

Selected air and precipitation samples are analyzed by gamma spectroscopy to determine the presence of fresh fission products. This method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the complex gamma spectra.

Results

Monthly values of gross beta activity in air, total deposition and depth of precipitation are given in table 1 for June 1965. Time profiles of gross beta activity in air for eight stations are shown in figure 2.

Five air samples contained gross beta activities greater than 5 pCi/m³; these were:

Location	Date	Activity at collection (pCi/m³)
El Paso, Texas	June 1	7.8
	June 2	5.6
Phoenix, Arizona	June 2	6.7
Las Vegas, Nevada	June 1	9.5
	June 2	6.7

Of the 1,903 air samples and 357 precipitation samples collected during June 1965, 266 air samples and one precipitation sample were analyzed by gamma spectroscopy. All of these contained the fresh fission products ^{140}BaLa, ^{95}ZrNb, ^{103}Ru and ^{141}Ce at low levels. In addition, long-lived radionuclides, including ^{144}CePr, ^{137}Cs, and ^{106}RuRh, were present.

Table 1. Gross beta activity in surface air and precipitation, June 1965

Station location		Air surveillance						Precipitation measurements	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD*	Total depth (mm)	Total deposition [b] (nCi/m²)
		Air	Pptn	Maximum	Minimum	Average [a]			
Ala:	Montgomery	30	10	1.62	<0.10	<0.53	May 65	100.9	<20.5
Alaska:	Adak	27		0.17	<0.10	<0.11	Sep 65	NS	
	Anchorage	29	7	0.32	<0.10	<0.14	May 65	21.9	<4.6
	Attu Island	25		0.33	<0.10	<0.14	Dec 64	NS	
	Fairbanks	21	5	0.56	<0.10	<0.21	Jun 65	26.3	<6.9
	Juneau	20	6	0.43	<0.10	<0.15	Jul 65	91.7	<18.4
	Kodiak	14		0.21	<0.10	<0.12	Aug 65	NS	
	Nome	NS					Feb 65		
	Point Barrow	30		0.25	<0.10	<0.13	Jan 65	NS	
	St. Paul Island	29		0.29	<0.10	<0.11	Mar 65	NS	
Ariz:	Phoenix	29		6.07	0.20	1.60	Jul 65	NS	
Ark:	Little Rock	26	5	1.36	0.15	0.70	Jun 65	57.5	<12.4
Calif:	Berkeley	28		0.39	<0.10	<0.23	Aug 65	NS	
	Los Angeles	30		1.32	0.18	0.38	Feb 65	NS	
C. Z:	Ancon	NS					Aug 65		
Colo:	Denver	27	4	4.30	0.19	1.03	Aug 65	69.8	<17.0
Conn:	Hartford	30	5	1.03	<0.10	<0.46	Jul 65	37.2	<8.5
Del:	Dover	22		0.79	0.16	0.44	May 65	NS	
D. C:	Washington	27	5	0.91	0.14	0.50	Feb 65	25.8	<7.1
Fla:	Jacksonville	28	10	0.76	<0.10	<0.31	Jun 65	221.5	<44.4
	Miami	23	9	1.62	<0.10	0.44	Jul 65	215.0	<43.1
Ga:	Atlanta	4		0.94	0.62	0.81	Apr 65	NS	
Guam:	Agana	25		4.45	<0.10	0.55	Apr 65	NS	
Hawaii:	Honolulu	30	2	0.66	<0.10	<0.27	Dec 64	18.0	<5.6
Idaho:	Boise	28	4	2.22	0.21	0.72	Dec 64	25.0	<8.1
Ill:	Springfield	29	6	1.03	0.22	0.60	Feb 65	101.2	<20.3
Ind:	Indianapolis	22	4	1.11	0.15	0.58	Apr 65	59.6	<15.3
Iowa:	Iowa City	30	6	1.12	0.22	0.60	Aug 65	78.6	<15.1
Kans:	Topeka	26	9	1.87	0.12	0.70	May 65	208.6	<56.3
Ky:	Frankfort	26	7	1.58	0.25	0.71	Feb 65	37.1	<8.5
La:	New Orleans	30	10	2.21	<0.10	<0.53	Feb 65	131.3	<27.9
Maine:	Augusta	30	9	1.00	<0.10	0.57	Mar 65	57.0	<12.9
	Presque Isle	22	7	1.27	0.12	0.50	Aug 65	49.9	<10.7
Md:	Baltimore	22	3	0.89	0.15	0.52	Jul 65	30.0	6.4
	Rockville	10		1.00	0.25	0.49	Jan 65	NS	
Mass:	Lawrence	29	7	1.34	<0.10	0.59	May 65	65.9	<22.2
	Winchester	28	9	1.17	<0.10	<0.49	Sep 65	86.6	<23.9
Mich:	Lansing	29	9	1.40	0.15	0.60	Jan 65	56.9	<12.2
Minn:	Minneapolis	21	8	0.89	0.27	0.49	Apr 65	152.9	<48.8
Miss:	Jackson	29	3	1.90	<0.10	0.75	Dec 64	33.2	<9.5
	Pascagoula	13		2.14	<0.10	0.71	Sep 65	NS	
Mo:	Jefferson City	30	8	1.33	0.13	0.66	Apr 65	168.0	<48.1
Mont:	Helena	30	10	2.35	<0.10	0.85	Sep 65	70.7	<16.7
Nebr:	Lincoln	17	1	1.40	<0.10	<0.46	Mar 65	29.8	<6.0
Nev:	Las Vegas	22		9.49	0.18	1.82	Jun 65	NS	
N. H:	Concord	22		1.80	<0.10	0.72	Feb 65	NS	
N. J:	Trenton	29	3	1.05	<0.10	0.52	Mar 65	12.0	<2.4
N. Mex:	Santa Fe	25	10	2.50	0.11	0.70	Sep 65	57.9	<15.6
N. Y:	Albany	21	9	1.20	<0.10	<0.59	Apr 65	36.1	<7.2
	Buffalo	24		1.62	<0.10	0.67	Aug 65	NS	
	New York	30		1.27	<0.10	0.44	Sep 65	NS	
N. C:	Gastonia	29	8	0.98	<0.10	<0.37	Aug 65	127.1	<25.4
N. Dak:	Bismarck	27	11	1.13	0.12	0.61	Jan 65	87.2	<22.1
Ohio:	Cincinnati	14		0.69	0.14	0.39	May 65	NS	
	Columbus	28	7	1.75	0.31	0.85	Mar 65	25.2	<7.0
	Painesville	30	8	1.83	<0.10	0.69	Jul 65	96.3	<20.4
Okla:	Oklahoma City	26		1.58	0.13	0.61	Jan 65	NS	
	Ponca City	28	11	1.14	<0.10	<0.34	Oct 65	121.4	<27.1
Ore:	Portland	28	4	1.02	0.17	0.45	Mar 65	16.2	<3.3
Pa:	Harrisburg	30	2	1.79	0.13	0.48	Apr 65	27.6	7.5
P. R:	San Juan	29	4	1.25	<0.10	0.46	Mar 65	143.2	<28.6
R. I:	Providence	28	5	1.01	<0.10	0.53	Jan 65	48.0	<10.6
S. C:	Columbia	25	12	0.66	<0.10	<0.30	Sep 65	212.3	<44.2
S. Dak:	Pierre	30	6	1.77	0.20	0.59	Jul 65	22.8	<9.5
Tenn:	Nashville	30	10	1.35	<0.10	0.52	Jan 65	87.8	<29.1
Tex:	Austin	30	5	1.54	<0.10	<0.50	May 65	30.7	<8.3
	El Paso	27	2	7.70	0.13	1.17	Jan 65	13.2	<3.4
Utah:	Salt Lake City	29	8	4.85	<0.10	1.70	Feb 65	133.3	<33.9
Vt:	Barre	26	8	1.33	<0.10	0.57	Jun 65	81.0	<20.2
Va:	Richmond	30	9	0.81	<0.10	0.43	Jun 65	95.1	<20.3
Wash:	Seattle	29	3	0.51	<0.10	0.34	May 65	11.1	4.9
	Spokane	30	1	1.44	0.11	0.62	Apr 65	13.2	<2.6
W. Va:	Charleston	28	7	0.94	0.12	0.50	Sep 65	54.7	<16.4
Wis:	Madison	30	6	1.13	0.18	0.47	Jun 65	38.6	<12.0
Wyo:	Cheyenne	29	8	3.75	0.20	1.02	Jun 65	98.2	60.4
Network summary [c]		1,903	357	9.49	<0.10	<0.56		74.6	<18.5

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.

[b] If any individual precipitation samples have activity concentrations under 200 pCi/liter, a "less than" sign is placed before the total deposition value.

[c] For the network summary, all averages are arithmetic means of station averages.

Key to symbols: NS, no sample collected. Blank indicates no report received.

6

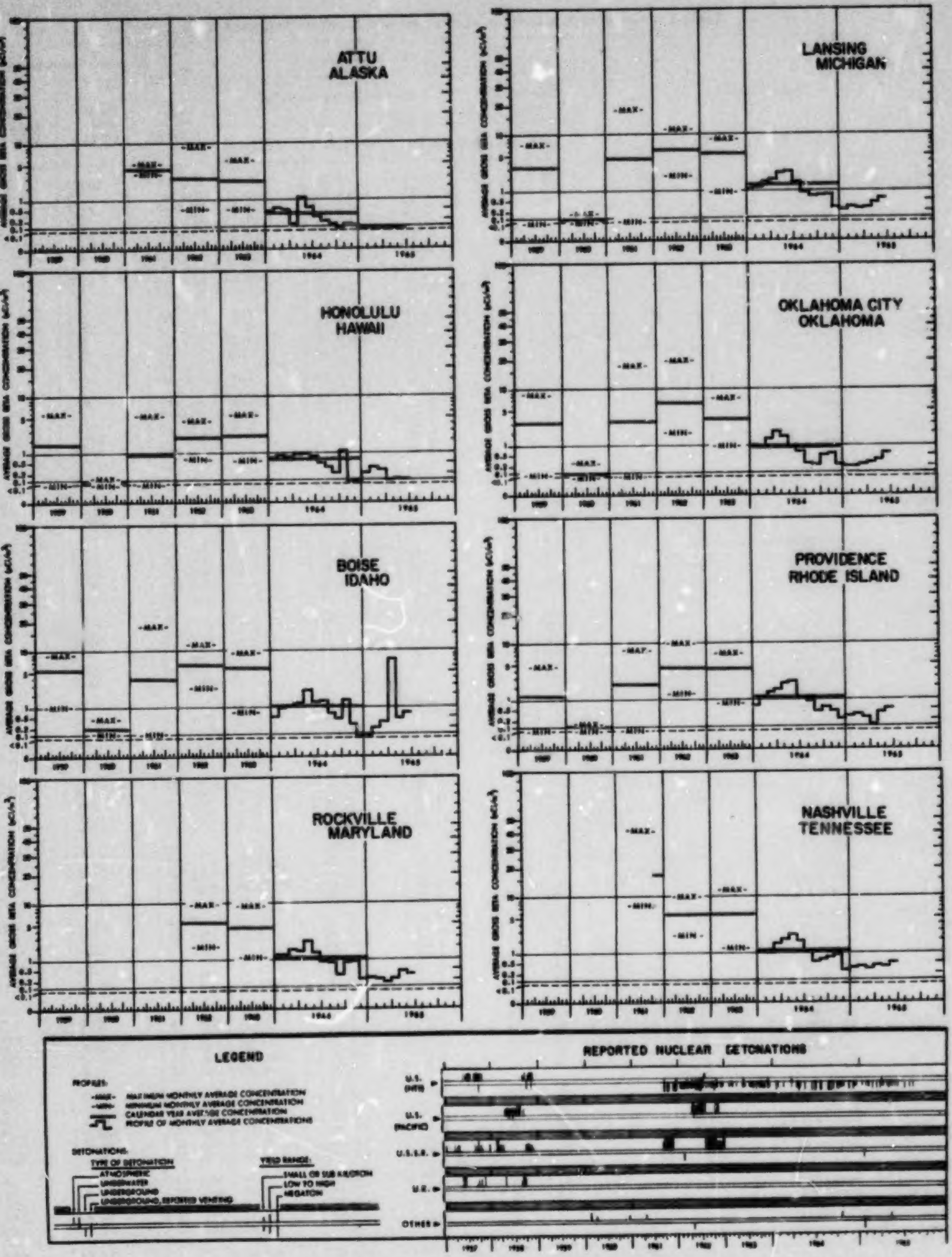

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959–June 1965

7

2. National Air Sampling Network Second Quarter 1965

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. The resulting data aid in the detection of trends in levels of pollution with respect to time, location, population density, climate and other factors.

Gross beta activity in air

NASN stations (figure 3) are manned by cooperating Federal, State and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, the NASN consists of 240 sampling stations, 175 of which are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass-fiber filters on a biweekly random sampling schedule. They are sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Second quarter 1965 gross beta activities in air are given in table 2. An annual summary for 1964 was presented in the April 1965 issue of Radiological Health Data (*5*).

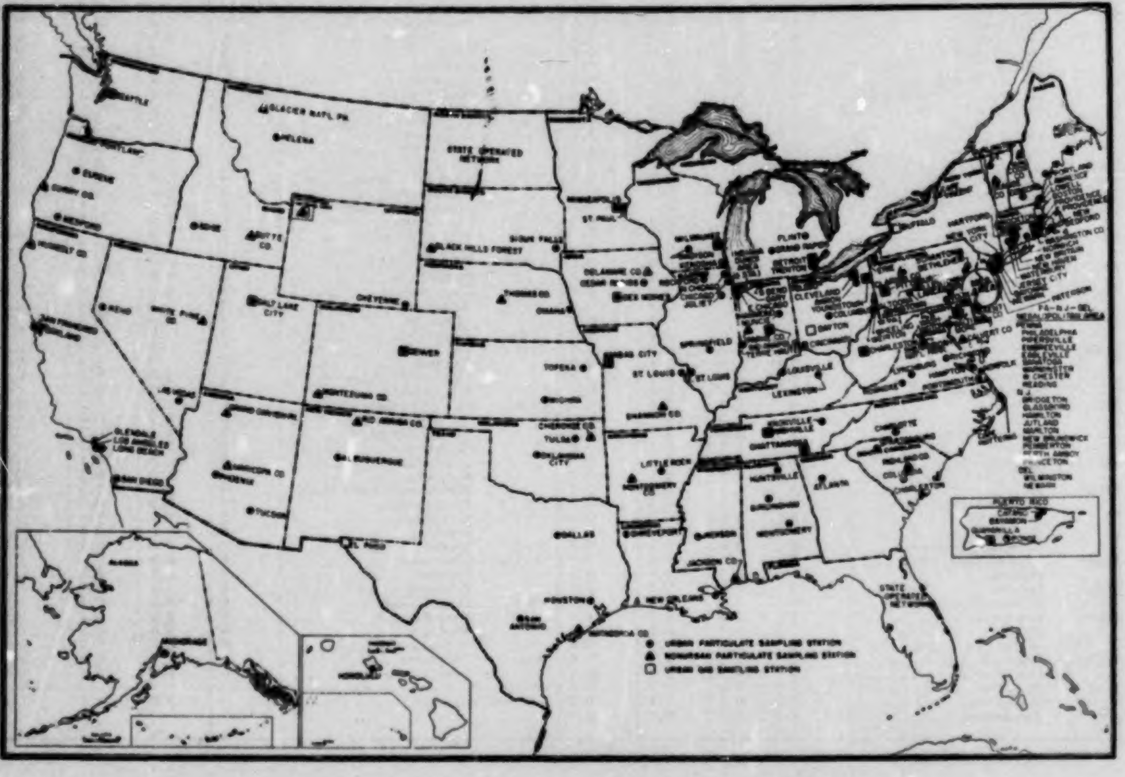
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
☐ URBAN GAS SAMPLING STATION

Figure 3. National Air Sampling Network stations

Table 2. Gross beta activity in surface air, NASN, second quarter 1965

(Concentrations in pCi/m³)

	Station Name	Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	6	1.1	0.4	0.6
	Huntsville	6	1.1	0.2	0.7
	Montgomery	7	1.1	0.3	0.6
Alaska:	Anchorage	6	0.4	<0.1	0.2
Ariz:	Grand Canyon Park *	7	1.3	0.4	0.9
	Paradise Valley *	5	2.0	0.6	1.1
	Phoenix	6	1.7	0.6	1.1
	Tucson	7	3.6	0.5	1.0
Ark:	Little Rock	4	1.4	0.2	0.8
	Montgomery County *	6	0.7	0.1	0.4
Calif:	Glendale	7	1.1	0.3	0.6
	Humboldt County *	7	0.3	0.1	0.2
	Long Beach	6	1.0	0.3	0.6
	Los Angeles	6	1.0	0.3	0.5
	Oakland	5	0.3	0.2	0.2
	San Diego	7	0.8	0.3	0.5
	San Francisco	7	0.4	0.2	0.4
Colo:	Denver	5	1.6	0.2	0.7
	Montezuma County *	7	1.4	0.6	0.9
Conn:	Hartford	6	1.1	0.1	0.6
	New Britain	6	1.2	0.2	0.7
	New Haven	6	1.2	0.2	0.6
	Norwich	6	1.2	0.1	0.6
	Waterbury	6	1.3	0.2	0.6
Del:	Kent County *	5	0.9	0.2	0.5
	Newark	5	1.3	0.2	0.6
	Wilmington	6	1.1	0.2	0.6
D. C:	Washington	6	1.3	0.1	0.6
Ga:	Atlanta	6	0.9	0.3	0.6
Hawaii:	Honolulu	7	3.0	0.1	1.1
Idaho:	Boise	6	1.2	0.5	0.9
	Butte County *	5	1.4	0.6	0.8
Ill:	Chicago	7	0.8	0.2	0.5
	East St. Louis	6	1.5	0.4	0.9
	Joliet	6	0.6	0.3	0.5
	North Chicago	5	0.9	0.2	0.5
	Rockford	7	0.9	0.3	0.6
	Springfield	6	0.7	0.3	0.5
Ind:	East Chicago	6	0.8	0.2	0.5
	Hammond	5	0.9	0.2	0.6
	Indianapolis	6	1.2	0.3	0.6
	Parke County *	6	1.1	0.2	0.6
	Portage	5	1.1	0.4	0.7
	Beverly Shores	6	0.8	0.2	0.6
	Dunes Police Post No. 1	6	1.0	0.3	0.6
	Dunes State Park	5	1.0	0.2	0.5
	Ogden Dunes	5	0.6	0.1	0.4
	South Bend	5	1.8	0.5	1.0
	Terre Haute	5	1.5	0.7	1.1
Iowa:	Cedar Rapids	6	0.6	0.2	0.4
	Delaware County *	5	0.6	0.2	0.4
	Des Moines	6	1.1	0.2	0.5
Kans:	Topeka	6	1.6	0.2	0.7
	Wichita	6	1.0	0.3	0.6
Ky:	Lexington	5	1.4	0.2	0.7
	Louisville	5	0.6	0.2	0.4
La:	New Orleans	6	1.3	0.4	0.7
	Shreveport	6	1.3	0.2	0.7
Maine:	Acadia Nat'l. Park *	6	0.7	0.2	0.5
	Portland	5	1.3	0.2	0.5
Md:	Baltimore	6	1.6	0.1	0.7
	Calvert County *	6	0.8	0.1	0.5
Mass:	Brockton	6	1.2	0.2	0.6
	Lawrence	6	2.0	0.1	0.8
	Lowell	6	2.0	0.2	1.0
	New Bedford	5	1.5	0.1	0.7
Mich:	Detroit	6	1.5	0.4	0.8
	Flint	5	1.3	<0.1	0.6
	Grand Rapids	6	0.8	0.2	0.5
	Trenton	5	1.3	0.4	0.8
Minn:	Minneapolis	7	0.8	0.1	0.4
	St. Paul	6	0.8	0.1	0.4
Miss:	Jackson	6	1.6	0.2	0.7
	Jackson County *	6	1.4	0.2	0.6
Mo:	Kansas City	5	0.6	0.3	0.4
	St. Louis	5	1.2	0.4	0.6
	Shannon County *	6	0.9	0.1	0.5
Mont:	Glacier Nat'l. Park *	5	1.0	0.2	0.6
	Helena	5	1.4	0.5	0.9
Nebr:	Omaha	5	0.8	0.3	0.6
	Thomas County *	6	0.9	0.1	0.5
Nev:	Las Vegas	6	1.9	0.7	1.2
	Reno	7	1.4	0.5	1.0
	White Pine County *	6	1.4	0.4	0.8
N. H:	Concord	6	1.0	0.2	0.6
	Coos County *	5	0.8	0.3	0.4
N. J:	Bayonne	6	1.8	0.2	0.8
	Bridgeton	5	0.5	0.1	0.3
	Pemberton	6	1.0	0.3	0.7
	Marlton	6	1.3	0.1	0.8
	Glassboro	5	1.1	0.1	0.6
	Hamilton	6	1.4	0.1	0.8
	Jutland	6	1.1	0.1	0.5
	Jersey City	6	1.3	0.1	0.6
	Newark	6	2.0	0.1	0.7
	New Brunswick	6	0.9	0.1	0.6
	Paterson	6	1.8	0.1	0.7
	Perth Amboy	5	1.6	0.2	0.8
	Princeton	5	0.7	0.2	0.5
N. Mex:	Albuquerque	6	1.6	0.3	1.0
	Rio Arriba County *	6	2.6	0.5	1.2
N. Y:	Cape Vincent *	6	1.2	0.3	0.6
	New York City	5	1.2	0.2	0.5
N. C:	Charlotte	6	1.0	0.4	0.6
	Cape Hatteras *	5	0.8	0.2	0.4
Ohio:	Akron	6	1.3	0.4	0.8
	Cincinnati	6	1.2	0.4	0.7
	Cleveland	5	3.6	0.5	1.4
	Columbus	6	1.4	0.5	0.8
	Toledo	6	1.5	0.4	0.9
	Youngstown	6	1.3	0.5	0.8
Okla:	Cherokee County *	5	1.3	0.2	0.8
	Oklahoma City	6	0.9	0.2	0.5
	Tulsa	6	0.8	0.2	0.5
Ore:	Curry County *	7	0.4	0.1	0.3
	Eugene	6	0.5	0.1	0.3
	Medford	6	0.8	0.1	0.6
	Portland	5	0.5	0.2	0.3
Pa:	Allentown	5	1.7	0.1	0.5
	Altoona	6	1.4	0.4	1.0
	Bethlehem	6	2.0	0.1	0.8
	Pipersville	6	1.7	0.1	0.6
	Embreeville	5	1.0	0.2	0.5
	Clarion County *	6	1.8	0.3	0.8
	Erie	6	1.6	0.4	0.8
	Johnstown	6	0.8	0.2	0.6
	Lancaster	6	1.1	0.1	0.7
	Eagleville	6	1.2	0.2	0.6
	Sanatoga	6	1.8	0.1	0.6
	Philadelphia	6	1.1	0.3	0.5
	Pittsburgh	6	1.2	0.4	0.7
	Reading	6	2.1	0.1	0.6
	Warminster	6	2.9	0.2	0.9
	West Chester	5	0.8	0.2	0.5
	York	6	1.4	0.3	0.9
P. R:	Bayamon	7	2.0	0.3	0.6
	Guayanilla	6	0.7	0.1	0.3
	Ponce	5	1.1	0.2	0.4
	San Juan	4	0.9	0.2	0.5
R. I:	East Providence	6	0.8	<0.1	0.4
	Providence	6	2.0	0.3	0.8
	Washington County *	6	1.4	0.2	0.7
S. C:	Charleston	6	1.1	0.2	0.6
	Richland County *	5	0.8	0.1	0.4
	Spartanburg	7	1.3	0.2	0.7
S. Dak:	Black Hills Forest *	6	0.9	0.2	0.7
	Sioux Falls	6	0.8	0.1	0.4
Tenn:	Chattanooga	6	1.2	0.4	0.8
	Knoxville	6	1.2	0.4	0.7
	Memphis	6	1.1	0.1	0.6
	Nashville	6	1.0	0.3	0.6
Tex:	Dallas	6	1.8	0.2	0.8
	Houston	6	1.0	0.4	0.6
	Matagorda County *	7	1.0	0.2	0.5
	San Antonio	6	0.6	0.2	0.4
Utah:	Salt Lake City	5	2.5	0.2	0.9
Vt:	Burlington	6	1.2	0.1	0.6
	Orange County *	5	1.4	0.3	0.8
Va:	Hampton	6	1.3	0.3	0.6
	Lynchburg	6	1.2	0.1	0.7
	Norfolk	7	1.5	0.3	0.7
	Shenandoah Nat'l. Park *	6	1.2	0.3	0.7
	Portsmouth	6	0.8	0.3	0.5
	Richmond	6	1.5	0.4	0.8
	Roanoke	6	1.0	0.4	0.7
Wash:	Seattle	7	0.8	0.2	0.4
W. Va:	Charleston	6	0.8	0.1	0.5
	Weirton	6	1.2	0.5	0.8
	Wheeling	6	1.3	0.5	0.8
Wis:	Door County *	6	0.8	0.1	0.5
	Kenosha	6	2.0	0.2	0.9
	Madison	6	1.0	0.2	0.6
	Milwaukee	6	0.8	0.2	0.5
Wyo:	Cheyenne	6	1.4	0.2	0.8
	Yellowstone Park *	6	1.1	0.4	0.8
Network summary			3.6	<0.1	0.7

* Denotes nonurban station.

3. Canadian Air and Precipitation Monitoring[2] June 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 4) are located at airports, where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*6-10*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa.

For analysis purposes a 2-inch diameter disk is cut from each filter and counted with a thin-end window, glass-flow, Geiger-Mueller counter system calibrated with a strontium–90—yttrium–90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for June 1965 are given in table 3.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter, together with the polyethylene liner, is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin-end window, Geiger-Mueller counter calibrated with a strontium–90—yttrium–90 source. Gross beta activities in precipitation for June 1965 are given in table 3.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. Where the June 1965 gross beta deposition is given in table 3, the deposi-

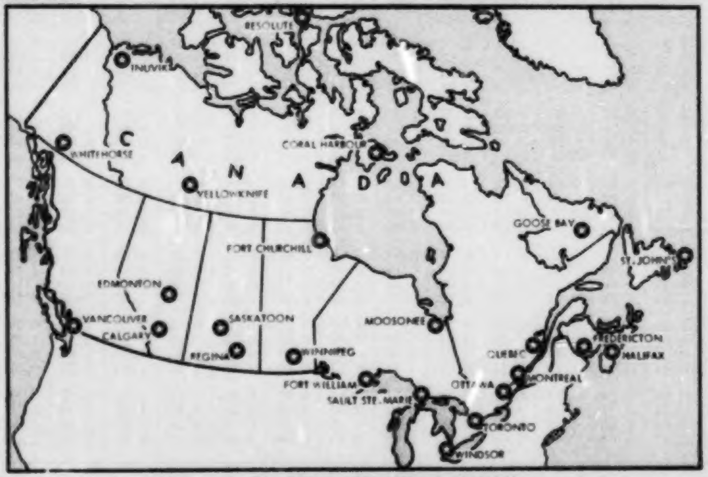

Figure 4. Canadian air and precipitation sampling stations

tion of selected radionuclides per unit area is given in table 4 for the period January through June 1965. A review and discussion of fallout levels in Canada during 1964 has been presented by Booth, *et al.* (*11*).

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[2] Prepared from information and data in the July 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 3. Canadian gross beta activity in surface air and precipitation, June 1965

Station	Air surveillance				Precipitation measurements	
	Number of samples	Maximum (pCi/m³)	Minimum (pCi/m³)	Average (pCi/m³)	Average concentration, (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	3.2	0.1	1.1	240	40.8
Coral Harbour	30	0.2	0.0	0.1	369	0.9
Edmonton	30	2.4	0.1	0.7	114	21.7
Ft. Churchill	30	0.9	0.0	0.2	443	6.2
Ft. William	30	1.7	0.1	0.5	255	20.5
Fredericton	30	1.8	0.0	0.6	105	4.5
Goose Bay	30	2.1	0.0	0.3	160	22.9
Halifax	30	0.8	0.0	0.4	66	6.9
Inuvik	30	1.9	0.0	0.4	381	8.0
Montreal	30	3.6	0.1	0.8	415	7.7
Moosonee	30	1.5	0.0	0.3	398	12.7
Ottawa	30	2.1	0.0	0.7	567	10.3
Quebec	29	3.2	0.1	0.6	301	14.6
Regina	30	2.6	0.1	1.0	192	24.2
Resolute	27	0.2	0.0	0.1	52	1.4
St. John's, Nfld	28	2.5	0.0	0.5	137	9.5
Saskatoon	28	0.8	0.0	0.3	83	8.4
Sault Ste. Marie	25	1.5	0.1	0.5	196	17.6
Toronto	29	1.8	0.1	0.5	159	6.8
Vancouver	30	1.6	0.1	0.4	353	4.7
Whitehorse	30	1.9	0.0	0.3	324	4.7
Windsor	30	2.3	0.1	0.9	172	7.3
Winnipeg	30	2.8	0.1	0.6	288	17.3
Yellowknife	17	1.2	0.0	0.4	334	11.7
Network summary		3.6	0.0	0.5	254	12.1

Table 4. Radionuclide deposition (nCi/m²) in Canadian fallout, January–June 1965[a]

Station	Strontium-89		Strontium-90						Cesium-137						Zirconium-95		Barium-140	
	May	June	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June	May	June	May	June
Calgary	0.20	5.06	0.06	0.13	0.16	0.24	0.53	2.46	0.13	0.23	0.28	0.41	0.92	3.01	0.10	2.22	0.67	4.07
Coral Harbour	0.00	0.10	0.11	0.06	0.11	0.07	0.23	0.00	0.19	0.12	0.19	0.16	0.54	0.03				
Edmonton	0.97	2.48	0.17	0.15	0.06	0.30	0.98	1.65	0.22	0.23	0.13	0.56	1.74	1.65				
Ft. Churchill	0.00	0.80	0.06	0.15	0.03	0.14	0.29	0.40	0.10	0.10	0.13	0.23	0.65	0.60				
Ft. William	9.30	2.32	0.07	0.32	0.25	0.57	1.10	1.56	0.15	0.55	0.33	0.80	1.81	1.74				
Fredericton	0.56	1.42	0.21	0.20	0.06	0.44	0.55	0.77	0.33	0.52	0.16	0.68	1.10	1.20				
Goore Bay	0.10	2.48	0.29	0.16	0.19	0.10	0.36	1.51	0.26	0.27	0.22	0.65	0.59	2.00				
Halifax	0.96	1.17	0.60	0.24	0.18	0.62	0.62	0.43	1.72	0.62	0.48	0.76	1.16	0.64	0.12	0.22	1.72	0.87
Inuvik	0.00	0.80	0.06	0.03	0.11	0.16	0.28	0.41	0.16	0.11	0.19	0.20	0.45	0.75				
Montreal	0.99	0.76	0.26	0.24	0.12	0.39	0.61	0.36	0.42	0.44	0.21	0.69	0.98	0.67	1.45	0.58	3.20	0.69
Moosonee	1.95	1.83	0.09	0.04	0.04	0.17	0.84	0.51	0.15	0.08	0.12	0.46	1.34	1.05				
Ottawa	0.33	0.85	0.15	0.13	0.06	0.56	0.49	0.45	0.35	0.54	0.20	0.75	0.75	0.61				
Quebec	1.03	1.41	0.26	0.53	0.28	0.33	0.87	0.88	0.62	1.40	0.57	0.93	1.53	1.19				
Regina	1.39	2.03	0.04	0.12	0.14	0.29	0.76	1.58	0.11	0.25	0.25	0.58	1.49	1.94				
Resolute	0.00	0.24	0.06	0.32	0.11	0.00	0.05	0.00	0.15	0.50	0.20	0.00	0.10	NA				
St. John's, Nfld	0.35	1.25	0.48	0.27	0.63	0.70	0.61	0.63	0.96	0.35	1.12	1.07	0.93	0.88				
Saskatoon	1.23	1.61	0.04	0.05	0.07	0.15	0.55	1.00	0.12	0.07	0.18	0.36	1.30	0.74				
Sault Ste. Marie	0.57	1.29	0.24	0.14	0.06	0.62	1.07	0.80	0.61	0.73	0.23	1.20	1.56	1.30				
Toronto	0.33	0.57	0.49	0.45	0.30	0.77	0.50	0.37	0.97	0.69	0.50	1.39	0.96	0.57				
Vancouver	0.38	0.44	0.59	1.16	0.54	0.77	0.84	0.18	0.90	1.78	1.01	1.23	1.30	0.37	2.19	0.26	1.80	0.51
Whitehorse	0.00	0.38	0.04	0.02	0.07	0.07	0.11	0.15	0.07	0.04	0.14	0.16	0.22	0.32				
Windsor	3.20	0.78	0.47	0.28	0.51	0.73	0.81	0.31	1.06	0.40	0.80	1.18	1.30	0.37				
Winnipeg	2.73	2.08	0.03	0.12	0.07	0.61	1.41	1.09	0.13	0.18	0.09	0.91	2.28	1.54	3.40	1.19	9.84	2.27
Yellowknife	0.17	0.77	0.04	0.02	0.08	0.05	0.08	0.90	0.06	0.06	0.15	0.20	0.17	1.23				

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[a] Samples from all stations are routinely analyzed for ^{89}Sr, ^{90}Sr, and ^{137}Cs; samples from five selected stations are regularly analyzed for ^{95}Zr and ^{140}Ba. Negligible results are not reported.
NA, no analysis.

4. Mexican Air Monitoring Program June 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*12-16*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new surveillance network. This network consists of 17 stations (see figure 5), 12 of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

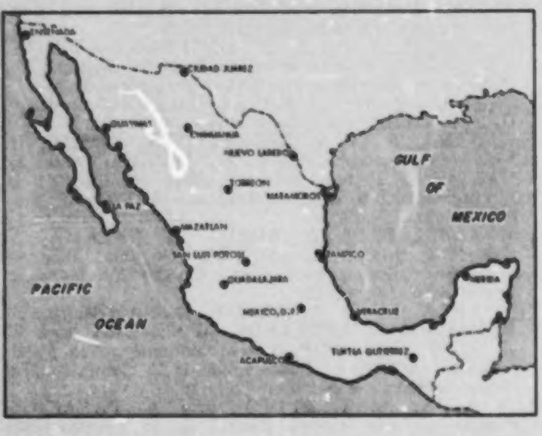

Figure 5. Fallout network sampling stations in Mexico

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- x 8-inch glass-fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radioactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated back to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during June 1965 are presented in table 5.

Table 5. Gross beta activity of airborne particulates, Mexico, June 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	4	0.3	0.1	0.2
Ciudad Juárez	15	6.5	0.1	0.9
Chihuahua	27	0.9	0.1	0.2
Ensenada	8	0.4	0.1	0.2
Guadalajara	4	<0.1	<0.1	<0.1
Guaymas	9	0.5	<0.1	0.2
La Paz	3	0.3	<0.1	0.2
Matamoros	2	0.3	0.2	0.2
Mazatlán	19	0.6	<0.1	0.3
Mérida	13	0.5	<0.1	0.1
México, D.F.	15	0.2	<0.1	<0.1
Nuevo Laredo	10	0.4	<0.1	0.2
San Luis Potosí	10	0.5	<0.1	0.3
Tampico	15	0.5	<0.1	0.1
Torreón	8	0.9	0.1	0.3
Tuxtla Gutiérrez [a]				
Veracruz	11	0.9	<0.1	0.2

[a] Station temporarily shut down.

5. Pan American Air Sampling Program June 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by five countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The five air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; and in Trinidad, West Indies, by the University of the West Indies.

The June 1965 air monitoring results from the five participating countries are given in table 6.

Table 6. Gross beta activity in surface air, June 1965 (concentrations in pCi/m^3).

Sampling stations	Number of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	18	0.10	<0.10	<0.10
Caracas, Venezuela	19	0.55	<0.10	<0.14
Lima, Peru	21	0.10	<0.10	<0.10
Santiago, Chile	26	0.13	<0.10	<0.10
Trinidad, West Indies	18	0.49	<0.10	<0.20

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

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(*16*) BRODY, T. A., S. BULBULIAN, J. CALVILLO, and A. M. MARTINEZ. Quinto informe sobre estudios de precipitación radiactiva. Revista Mexicana de Física 10: (1961).

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network
June 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from 1 day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analysis.

Analytical procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry.[1] After the weekly samples are gamma scanned, samples from 2 consecutive weeks are composited and analyzed radiochemically to determine strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

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from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

Table 1. Analytical errors associated with determinations of radionuclides concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	less than 100	10	100 or greater	10
Barium-140	less than 100	10	100 or greater	10
Cesium-137	less than 100	10	100 or greater	10
Strontium-89	less than 50	5	50 or greater	10
Strontium-90	less than 20	2	20 or greater	10

[a] Two standard deviations

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, 10; barium-140, 10; and iodine-131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations [2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for June 1965 (actual reporting period is May 30 through June 26). Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. A modified averaging procedure has been used for iodine-131 and barium-140 since October 1963, when nondetectable concentrations of these radionuclides began to be considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations.

The distribution of monthly average strontium-90 concentrations as observed in pasteurized milk for January through June 1965 is presented in table 3. The maximum monthly average concentration of strontium-90 was 48 pCi/liter, observed at Minot, North Dakota. This level is within the lower half of Range II

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[2] The conversion factor is 1.18 milligram, K/pCi^{40}K.

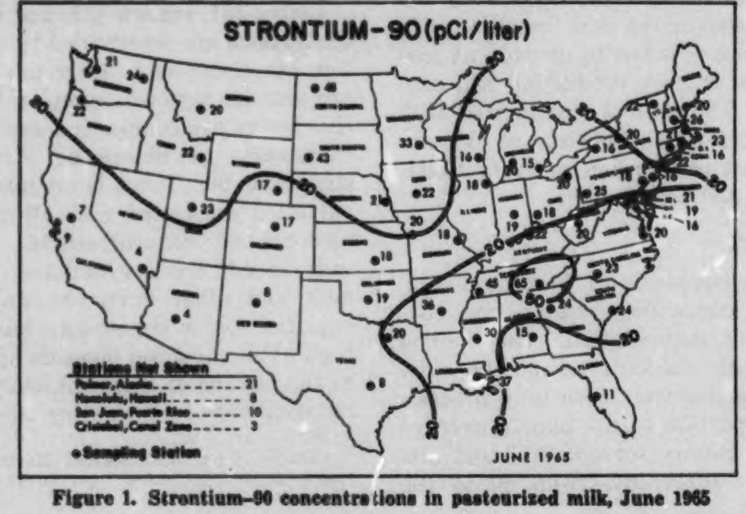

Figure 1. Strontium-90 concentrations in pasteurized milk, June 1965

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk, second quarter 1965 and June 1965[a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		Second quarter	Average for June	Second quarter	Average for June	Second quarter	Average for June	Second quarter	Average for June	Second quarter	Average for June
Ala:	Montgomery	1.17	1.14	<5	5	18	15	55	50	0	0
Alaska:	Palmer	1.22	1.23	<5	<5	20	21	65	50	0	0
Ariz:	Phoenix	1.21	1.23	<5	<5	5	4	20	20	0	0
Ark:	Little Rock	1.15	1.15	5	10	32	36	70	70	10	20
Calif:	Sacramento	1.25	1.25	<5	<5	8	7	35	25	0	0
	San Francisco	1.26	1.27	<5	<5	11	9	35	20	0	0
C. Z:	Cristobal	1.10	1.08	<5	<5	4	3	35	30	0	0
Colo:	Denver	1.33	1.33	<5	<5	19	17	70	65	0	10
Conn:	Hartford	1.11	1.10	<5	<5	15	16	75	60	0	0
Del:	Wilmington	1.14	1.12	<5	5	19	21	70	65	0	10
D. C:	Washington	1.15	1.10	5	10	17	16	55	55	10	20
Fla:	Tampa	1.16	1.14	<5	<5	12	11	175	170	0	0
Ga:	Atlanta	1.15	1.16	<5	5	20	24	85	70	0	10
Hawaii:	Honolulu	1.23	1.27	<5	<5	10	8	55	45	0	0
Idaho:	Idaho Falls	1.27	1.30	<5	<5	20	22	95	90	10	20
Ill:	Chicago	1.13	1.11	<5	<5	17	18	75	50	10	20
Ind:	Indianapolis	1.15	1.12	5	10	10	19	55	40	10	40
Iowa:	Des Moines	1.26	1.26	10	20	23	22	55	40	20	40
Kans:	Wichita	1.25	1.22	<5	5	18	18	50	50	10	20
Ky:	Louisville	1.15	1.13	5	15	24	22	45	35	10	30
La:	New Orleans	1.20	1.18	5	15	42	37	80	70	10	20
Maine:	Portland	1.17	1.11	<5	5	21	20	125	100	0	10
Md:	Baltimore	1.14	1.12	5	10	19	19	60	55	10	20
Mass:	Boston	1.13	1.12	<5	5	22	21	125	90	0	0
Mich:	Detroit	1.13	1.11	<5	5	17	15	75	50	10	20
	Grand Rapids	1.16	1.13	<5	5	19	20	80	65	10	20
Minn:	Minneapolis	1.29	1.32	10	25	28	33	90	75	20	60
Miss:	Jackson	1.18	1.18	5	10	34	30	55	55	0	10
Mo:	Kansas City	1.25	1.28	10	25	22	20	45	40	30	60
	St. Louis	1.20	1.06	5	10	19	18	45	35	20	40
Mont:	Helena	1.28	1.22	<5	<5	20	19	95	75	10	0
Nebr:	Omaha	1.19	1.15	5	15	21	21	50	45	20	40
Nev:	Las Vegas	1.28	1.28	<5	5	7	4	40	30	10	20
N. H:	Manchester	1.15	1.13	<5	<5	25	26	150	125	0	0
N. J:	Trenton	1.11	1.10	<5	<5	16	16	70	55	0	0
N. Mex:	Albuquerque	1.23	1.17	<5	<5	11	10	35	20	0	0
N. Y:	Buffalo	1.10	1.10	<5	<5	17	16	95	55	0	0
	New York	1.11	1.10	<5	<5	21	22	90	60	0	10
	Syracuse	1.10	1.10	<5	<5	18	20	80	50	0	10
N. C:	Charlotte	1.20	1.18	5	10	27	23	65	60	0	10
N. Dak:	Minot	1.27	1.30	10	20	57	48	120	120	10	20
Ohio:	Cincinnati	1.13	1.12	<5	5	18	18	50	35	10	20
	Cleveland	1.13	1.10	5	10	20	20	75	55	10	20
Okla:	Oklahoma City	1.12	1.08	5	15	20	19	45	45	10	30
Ore:	Portland	1.30	1.28	<5	<5	24	22	90	85	0	0
Pa:	Philadelphia	1.13	1.12	<5	5	19	18	65	50	0	0
	Pittsburgh	1.14	1.12	5	10	25	25	95	70	10	20
P. R:	San Juan	1.12	1.11	<5	5	11	10	50	50	0	10
R. I:	Providence	1.12	1.12	<5	5	20	23	95	80	0	0
S. C:	Charleston	1.16	1.11	<5	5	27	24	100	85	0	10
S. Dak:	Rapid City	1.05	1.22	10	25	33	43	105	85	10	40
Tenn:	Chattanooga	1.19	1.18	5	10	30	29	65	60	0	10
	Memphis	1.15	1.16	5	15	26	25	45	45	10	20
Tex:	Austin	1.12	1.06	<5	5	8	8	25	30	0	10
	Dallas	1.17	1.14	5	10	20	20	45	40	0	10
Utah:	Salt Lake City	1.39	1.38	<5	<5	26	23	120	105	10	30
Vt:	Burlington	1.12	1.11	<5	<5	21	22	100	75	0	0
Va:	Norfolk	1.17	1.14	5	10	21	20	60	55	10	10
Wash:	Seattle	1.27	1.25	<5	<5	25	26	105	110	0	0
	Spokane	1.30	1.31	<5	<5	27	24	90	70	0	0
W. Va:	Charleston	1.12	1.10	10	15	20	20	40	30	10	20
Wis:	Milwaukee	1.19	1.18	<5	5	17	16	85	60	10	20
Wyo:	Laramie	1.23	1.20	5	10	17	17	70	65	10	30
Network average		1.18	1.17	<5	10	20.7	20	72	61	6	15

[a] All station second quarter averages and all but two station monthly averages for barium-lanthanum-140 were 0. The stations were Chicago and Indianapolis for which the monthly average was 10 pCi/liter.

defined by the Federal Radiation Council (20–200 pCi/liter). The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

The Network average cesium–137 concentration in milk for June 1965 was 61 pCi/liter as compared to 74 pCi/liter in May 1965. The maximum monthly average concentration in pasteurized milk was 170 pCi/liter, observed at Tampa, Florida. The distribution of monthly average cesium–137 concentrations in milk for January through June 1965 is presented in table 4.

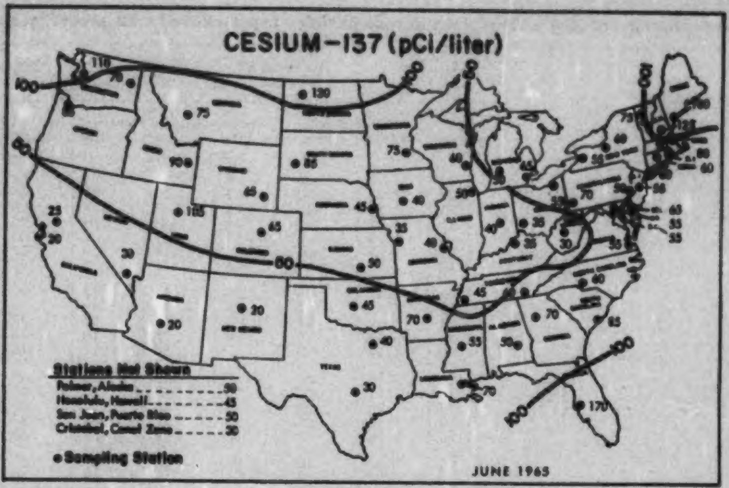
CESIUM-137 (pCi/liter)
Stations Not Shown
Palmer, Alaska 50
Honolulu, Hawaii 45
San Juan, Puerto Rico 50
Cristobal, Canal Zone 30
• Sampling Station
JUNE 1965
100
80
100
100

Figure 2. Cesium-137 concentrations in pasteurized milk, June 1965

The decrease in radionuclide concentrations in milk observed during January through June 1965 can be expected to continue in the absence of atmospheric nuclear testing. This trend is from March 1960 through 1964 (*2,3*).

During June 1965, iodine-131 was observed in weekly milk samples at 48 sampling stations (table 5). The maximum concentration observed was 130 pCi/liter on June 4, 1965. The levels of iodine-131 observed were

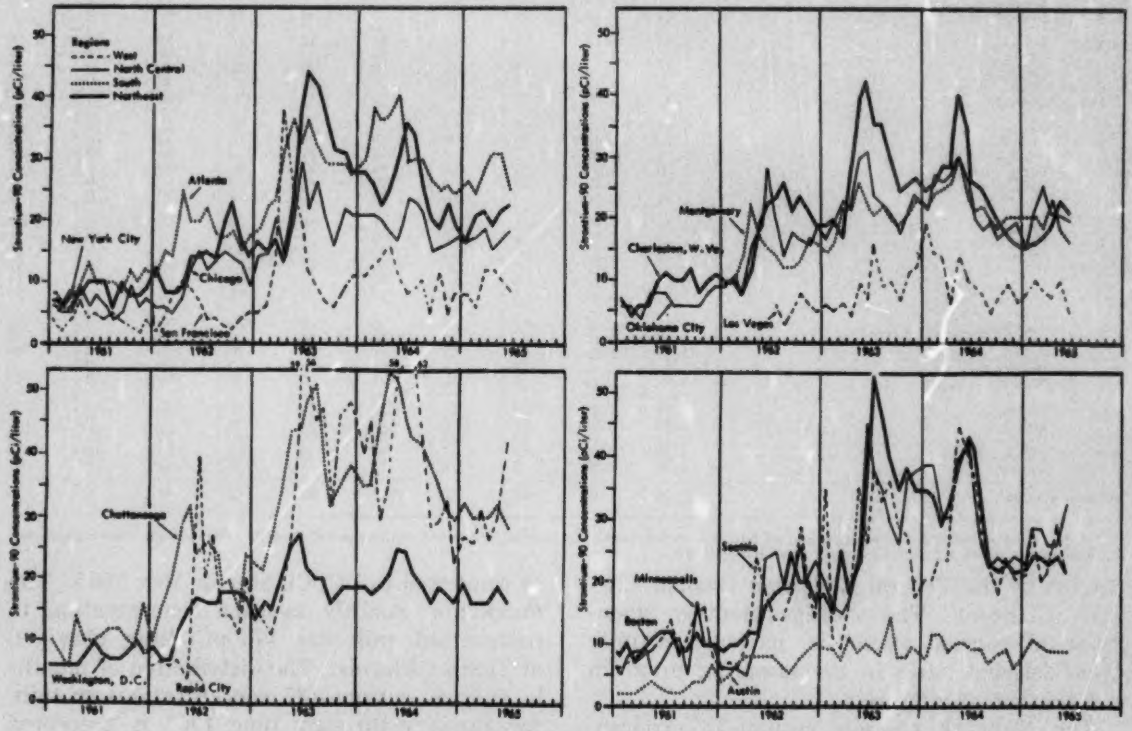

Figure 3. Strontium-90 concentrations in pasteurized milk, 1961-June 1965

such that 42 stations exhibited monthly averages greater than the detection limit of 10 pCi/liter. The highest monthly average, 60 pCi/liter observed in Kansas City, Missouri, was well within Range II as defined by the Federal Radiation Council (10–100 pCi/liter). The presence of iodine–131 in pasteurized milk during June 1965 is presumed a consequence of the mainland China atmospheric nuclear test on May 14, 1965.

Table 3. Frequency distribution of strontium-90 concentrations in milk at PMN stations, January–June 1965, and June 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	Jan	Feb	Mar	Apr	May	Jun	Jun
Under 10	6	3	5	5	4	7	4
10–19	32	31	29	23	26	21	6
20–29	19	22	21	27	25	29	23
30–39	4	5	6	5	5	4	17
40–49	1	2	1	2	2	2	10
50–59	1	0	1	0	0	0	2
60–69	0	0	0	1	1	0	10
70–79	0	0	0	0	0	0	1

Table 4. Frequency distribution of cesium-137 concentrations in milk at PMN stations, January–June 1965, and June 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	Jan	Feb	Mar	Apr	May	Jun	Jun
Under 50	11	8	9	7	17	19	1
50–99	38	38	36	35	31	38	19
100–149	12	15	16	18	13	5	24
150–199	2	2	2	3	2	1	13
200–249	0	0	0	0	0	0	4
250–299	0	0	0	0	0	0	2

Table 5. Occurrence of iodine-131 in Pastuerized Milk Network, June 1965

(Concentration in pCi/liter)

Sampling location		June, 1965																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ala:	Montgomery	---	---	---	---	---	---	---	---	---	20																				
Ark:	Little Rock	30	---	---	---	---	---	[illegible]	---	---	---	---	---	---	20																
Colo:	Denver	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	30						
Del:	Wilmington	---	---	30	---	---	---	---	---	---	20																				
D. C:	Washington	---	---	40	---	---	---	---	---	---	---	20	---	---	---	---	---	30													
Fla:	Tampa	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	10								
Ga:	Atlanta	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10														
Idaho:	Idaho Falls	40	---	---	---	---	---	---	---	---	---	---	---	---	40																
Ill:	Chicago	50	---	---	---	---	---	---	30	---	---	---	---	---	---	20															
Ind:	Indianapolis	80	---	---	---	---	---	40	---	---	---	---	---	---	30																
Iowa:	Des Moines	---	---	100	---	---	---	---	50	60	---	70																			
Kans:	Wichita	---	---	---	---	---	---	30	---	---	---	---	---	---	30																
Ky:	Louisville	60	---	---	---	---	---	40	---	---	---	---	---	---	30																
La:	New Orleans	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	20						
Me:	Portland	20	---	---	---	---	---	---	---	---	---	---	---	---	---	10															
Md:	Baltimore	30	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	10								
Mass:	Boston	10																													
Mich:	Detroit	60	---	---	---	---	---	---	20	---	---	---	---	---	---	20															
	Grand Rapids	40	---	---	---	---	---	20	---	---	---	---	---	---	20																
Minn:	Minneapolis	80	---	---	---	---	---	---	---	60	---	---	---	---	---	60	---	---	---	---	---	---	40								
Miss:	Jackson	---	---	---	---	---	---	60	---	---	---	---	---	---	20																
Mo:	Kansas City	---	---	---	130	---	---	60	---	60	---	50	---	---	---	---	---	---	60												
	St. Louis	---	---	40	---	---	---	---	---	---	60	---	---	---	---	---	---	50	---	---	---	---	---	---	20						
Nebr:	Omaha	---	---	---	70	---	---	---	---	---	---	40	---	---	---	---	---	---	30	---	---	---	---	---	20						
Nev:	Las Vegas	---	---	---	---	---	---	---	---	---	---	---	---	---	---	50															
N. H:	Manchester	20																													
N. J:	Trenton	---	---	---	---	---	---	---	---	---	---	---	---	---	---	10															
N. Y:	New York	20	---	---	---	---	---	---	---	---	---	---	---	---	20																
	Syracuse	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---	20														
N. C:	Charlotte	20	---	---	---	---	---	10																							
N. Dak:	Minot	---	---	---	---	---	---	60																							
Ohio:	Cincinnati	---	---	40	---	---	---	---	---	20	---	---	---	---	---	---	20														
	Cleveland	---	---	---	50	---	---	---	---	---	---	30																			
Okla:	Oklahoma City	---	40	---	---	---	---	---	---	40	---	---	---	---	---	---	20	---	---	---	---	---	---	10							
Pa:	Philadelphia	---	---	---	10	---	---	---	---	---	---	10																			
	Pittsburgh	40	---	---	---	---	---	30																							
P. R:	San Juan	---	---	---	---	---	---	20	---	---	---	---	---	---	10	---	---	---	---	---	---	10									
S. C:	Charleston	10	---	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10								
S. Dak:	Rapid City	---	---	---	---	---	---	60	---	---	---	---	---	---	50																
Tenn:	Chattanooga	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10														
	Memphis	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	20	---	---	---	---	---	---	10						
Tex:	Austin	---	---	---	---	---	---	---	---	---	---	20	---	---	---	---	---	---	10												
	Dallas	---	---	---	---	---	---	20	---	---	---	---	---	---	20																
Utah:	Salt Lake City	50	---	---	---	---	---	---	---	---	---	---	---	---	40	---	---	---	---	---	---	30									
Va:	Norfolk	---	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	10												
W. Va:	Charleston	---	---	---	40	---	---	---	---	---	---	30	---	---	---	---	---	---	20	---	---	---	---	---	---	10					
Wis:	Milwaukee	50	---	---	---	---	---	---	30	---	---	---	---	---	---	10															
Wyo:	Laramie	---	---	---	40	---	---	---	---	50	---	---	---	---	---	20															

2. Oklahoma Milk Network
March–July 1965

Oklahoma State Department of Health[3]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 4. There are ten milksheds in the State of Oklahoma. The five which were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) were selected on the basis of the size and location of their milksheds. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap will assist in locating any small areas of production where the iodine–131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk processing plant in the milkshed, and while the milkshed for that particular processing plant may not coincide exactly with that shown in figure 4, and coincidence is satisfactory for surveillance purposes.

Sampling

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine–131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about four hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

Analytical method

The method of analysis is similar to that recently published by the U. S. Public Health Service (4) but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory and has not been published to date.

The sampling stations are supplied with plastic cartridges containing 10 ml of Dowex 1X8, 50–100 mesh anion exchange resin. On the sampling date, one gallon of pasteurized whole milk is passed through the cartridge,

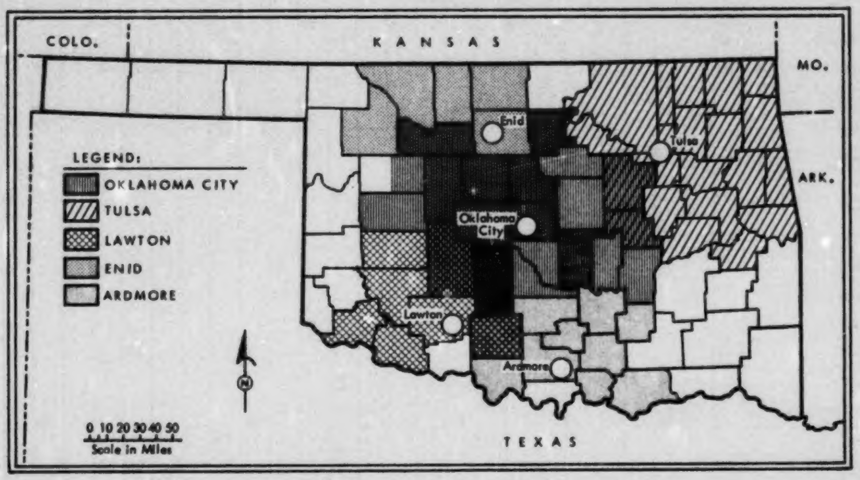

Figure 4. Milksheds of the five Oklahoma dairies used as sampling locations

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[3] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, Chief Engineer.

the residual milk is washed from the resin with distilled water, and the cartridge is mailed to the Radiological Health Laboratory where it is counted for 100 minutes in a 2- x 2-inch well type, thallium-activated sodium iodide crystal. The gamma energy is analyzed in a 400-channel analyzer. The results are corrected to noon of the sampling date. The minimum detectable concentration is 0.9 pCi/liter (3 standard deviations of background).

Results and discussion

Table 6 gives the concentrations of iodine-131 found in Oklahoma milk samples collected from the inception of the program through July 25, 1965.

The observed iodine-131 concentrations clearly reflect the arrival and subsequent decrease in fresh fission products which are presumed to have resulted from the second Chinese atmospheric nuclear test of May 14, 1965.

Table 6. Concentration of iodine-131 in Oklahoma milk, March to July, 1965

(Concentrations in pCi/liter)

Date	Sampling location				
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore
March 15	<1	<1	<1	<1	<1
22	<1	<1	<1	<1	<1
29	<1	<1	<1	<1	<1
April 5	IF	IF	IF	IF	IF
12	<1	<1	<1	<1	<1
19	<1	<1	<1	<1	NS
26	<1	<1	<1	<1	<1
May 3	<1	<1	NS	<1	<1
10	<1	<1	<1	<1	<1
17	<1	NS	<1	<1	NS
24	<1	<1	<1	<1	<1
31	<1	NS	NS	<1	3.9
June 7	37.4	41.0	24.6	35.4	32.8
14	16.7	20.6	16.9	15.8	14.0
21	5.1	7.5	4.9	8.3	NS
28	3.4	3.3	3.3	2.0	2.6
July 5	<1	NS	<1	<1	NS
12	<1	<1	<1	<1	NS
19	<1	<1	<1	<1	<1
25	<1	<1	<1	<1	<1

Key to Symbols: NS, no sample collected.
IF, instrument failure.

3. Texas Milk Network
January–March 1965

Texas State Department of Health [4]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "stand-by" stations have been supplied sample containers and shipping instructions and can be activated immediately, if needed. The "active" and "stand-by" station locations, shown in figure 5, were chosen to give maximum geographical and population coverage. The monthly grab samples are taken from tank trucks at the processing plants.

Analytical methods

Samples are routinely analyzed for iodine-131, barium-140, cesium-137, potassium-40, strontium-89, and strontium-90. The gamma-emitting radionuclides are analyzed using a 4- x 4-inch sodium iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3½ liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95 percent confidence level are 10 pCi/liter. Calcium determinations are not made.

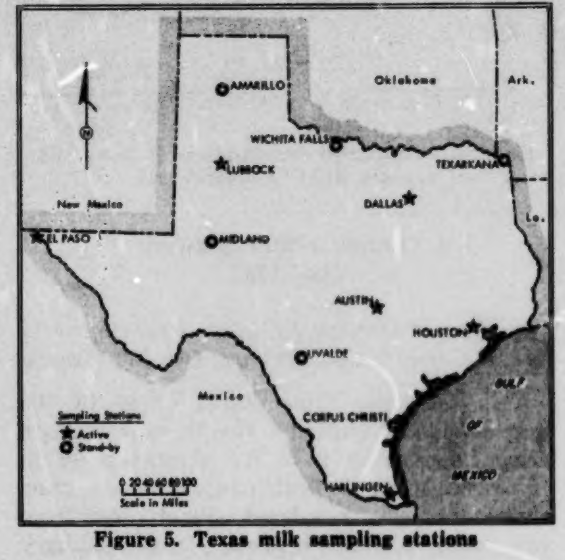

Figure 5. Texas milk sampling stations

Strontium-89 and strontium-90 are analyzed by a chemical separation technique using ion exchange columns (*5*). Prepared samples are counted for 100 minutes in a low-background beta counter.

Results

Potassium-40, strontium-90, and cesium-137 results by station and month for January and March are presented in table 7. During this time, the strontium-89 concentration was below the limit of detectability (5 pCi/liter). Iodine-131 and barium-140 were also below their limits of detectability (10 pCi/liter).

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[4] Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale Mchard, Head, and Mr. Robert Craig, Assistant Engineer.

Network average concentrations for April 1964 through March 1965 are shown in figure 6. Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*6*).

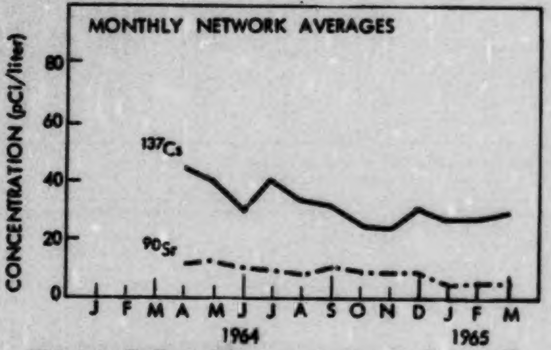

Figure 6. Radionuclide concentrations in Texas milk network, April 1964–March 1965

Table 7. Radionuclide concentrations in Texas Milk Network, January–March 1965

Sampling location	Potassium-40 (pCi/liter)		
	January	February	March
Austin	1280	1280	1350
Dallas	[a] NS	NS	NS
El Paso	1290	1300	1440
Harlingen	1410	1350	1370
Houston	1390	1370	1220
Lubbock	1340	1300	1330
Average	1342	1320	1342

Sampling location	Strontium-90 (pCi/liter)		
	January	February	March
Austin	4	7	6
Dallas	NS	NS	NS
El Paso	3	3	4
Harlingen	5	7	5
Houston	8	5	12
Lubbock	7	6	5
Average	5	6	6

Sampling location	Cesium-137 (pCi/liter)		
	January	February	March
Austin	20	40	30
Dallas	NS	NS	NS
El Paso	30	20	25
Harlingen	30	15	15
Houston	40	50	60
Lubbock	25	20	20
Average	29	29	30

[a] NS, no sample collected.

4. Canadian Milk Network[5]
June 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative monthly composite samples of milk consumed can be obtained, and milk sampling locations (figure 7) can be chosen in the same areas as the air and precipitation stations.

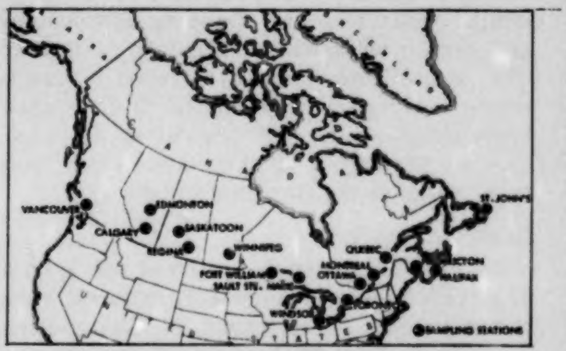

Figure 7. Canadian milk sampling stations

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales.

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[5] This report was prepared from information and data in the July 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

in most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-89, strontium-90, cesium-137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine-131 (*7*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle furnace at 450°C., and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low-background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potasium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the gamma spectrometric determination of cesium-137 no recovery factor is involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

Table 8. Total error for various radionuclide concentrations in milk [a]

Radionuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	25%	20%	15%
Strontium-90	15%	10%	10%
Iodine-131	30%	20%	10%
Cesium-137	60%	20%	10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 9 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

Table 9. Stable elements and radionuclides in Canadian whole milk, June 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.05	1.6	23.6	30.9	94
Edmonton	1.06	1.6	29.6	24.2	83
Ft. William	1.12	1.7	27.8	37.7	100
Fredericton	1.12	1.6	11.1	34.9	126
Halifax	1.08	1.6	19.6	36.7	119
Montreal	1.13	1.6	10.1	20.9	71
Ottawa	1.12	1.6	9.1	17.7	81
Quebec	1.12	1.6	12.7	36.8	130
Regina	1.12	1.5	20.1	31.2	70
St. John's, Nfld	1.13	1.4	9.8	53.9	204
Saskatoon	1.11	1.5	12.3	26.5	60
Sault Ste. Marie	1.11	1.6	9.2	36.1	106
Toronto	1.09	1.6	6.1	12.1	43
Vancouver	1.12	1.6	8.1	33.1	173
Windsor	1.08	1.6	12.1	12.4	42
Winnipeg	1.12	1.6	12.3	26.2	77
Average	1.11	1.6	14.6	29.5	99

5. Pan American Milk Sampling Program June 1965

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963, the program was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, additional stations were established in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde, and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the Condensery in Kingston. All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma scintillation spectrometry. Strontium–89, strontium–90 and barium–140 are determined radiochemically (*5*). Analytical errors are discused in the "Analytical Procedures, Pasteurized Milk Network" (see page 535).

Data presentation

Table 10 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations. The monthly average of iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

Table 10. Stable element and radionuclide concentrations in milk, PAHO, June 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone: Cristobal	1.08	1.5	<5	4	30
Jamaica: Kingston	1.16	1.42	<5	12	120
Mandeville	NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico: San Juan	1.15	1.5	<5	10	50
Venezuela: Caracas	1.15	1.28	<5	5	20

Key to symbols: NS, no sample collected.
Blanks indicate no report received.

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, JUNE 1964–JUNE 1965

Division of Radiological Health
Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3,4*).

Total dietary intake is of prime interest, and since the intake-via-milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 grams of calcium per liter in PMN samples and a 1.0 grams daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows:

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (*6*).

Table 1. Average radionuclide concentrations in milk for the twelve month periods,[a] June 1964–May 1965 and July 1964–June 1965

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)	
		June 1964–May 1965	July 1964–June 1965	June 1964–May 1965	July 1964–June 1965	June 1964–May 1965	July 1964–June 1965	June 1964–May 1965	July 1964–June 1965
Ala:	Montgomery	3	3	20	19	0	0	58	56
Alaska:	Palmer	3	3	19	16	1	1	85	78
Ariz:	Phoenix	3	3	5	5	0	0	24	24
Ark:	Little Rock	3	4	37	36	1	2	74	70
Calif:	Sacramento	3	3	7	7	1	1	33	31
	San Francisco	3	3	8	8	0	0	35	32
C. Z:	Cristobal	3	3	5	5	0	0	45	44
Colo:	Denver	3	3	19	18	0	1	80	77
Conn:	Hartford	3	3	18	18	0	0	98	91
Del:	Wilmington	3	3	19	19	1	2	81	76
D. C:	Washington	3	3	18	17	1	2	59	56
Fla:	Tampa	3	3	14	14	0	0	208	200
Ga:	Atlanta	3	3	27	27	0	1	96	92
Hawaii:	Honolulu	3	3	11	11	0	0	70	66
Idaho:	Idaho Falls	3	3	22	21	0	2	108	100
Ill:	Chicago	3	3	18	17	0	2	86	81
Ind:	Indianapolis	3	3	18	17	1	4	70	65
Iowa:	Des Moines	3	4	23	22	3	6	64	60
Kans:	Wichita	3	3	19	18	0	2	50	48
Ky:	Louisville	3	4	25	24	0	2	54	50
La:	New Orleans	4	5	44	43	0	2	94	88
Maine:	Portland	3	3	25	24	1	2	152	144
Md:	Baltimore	3	3	20	19	0	2	65	61
Mass:	Boston	3	3	26	25	0	0	154	142
Mich:	Detroit	3	3	17	16	2	3	85	81
	Grand Rapids	3	3	19	19	1	2	94	90
Minn:	Minneapolis	4	6	27	26	1	6	99	92
Miss:	Jackson	3	3	35	34	0	1	67	64
Mo:	Kansas City	3	5	23	23	4	8	54	50
	St. Louis	3	3	19	18	1	4	54	49
Mont:	Helena	3	3	19	18	3	3	103	97
Nebr:	Omaha	3	3	22	21	1	4	63	60
Nev:	Las Vegas	3	3	8	7	1	2	50	45
N. H:	Manchester	3	3	26	25	1	1	172	164
N. J:	Trenton	3	3	17	16	1	1	82	77
N. Mex:	Albuquerque	2	2	10	10	1	1	45	42
N. Y:	Buffalo	3	3	18	17	0	0	107	100
	New York	3	3	22	21	1	2	110	102
	Syracuse[b]	3	3	16	16	0	1	94	86
N. C:	Charlotte	3	3	34	32	0	1	79	74
N. Dak:	Minot	5	6	51	49	0	2	129	124
Ohio:	Cincinnati	3	3	18	18	0	2	64	59
	Cleveland	3	3	19	18	1	2	89	83
Okla:	Oklahoma City	3	4	20	19	0	2	51	49
Ore:	Portland	4	3	26	24	0	0	121	111
Pa:	Philadelphia	3	3	18	17	0	0	79	74
	Pittsburgh	3	3	27	25	0	2	110	101
P. R:	San Juan	3	3	12	11	0	1	58	56
R. I:	Providence	3	3	20	20	0	0	116	108
S. C:	Charleston	3	3	30	29	0	1	100	98
S. Dak:	Rapid City	4	5	34	33	0	3	126	119
Tenn:	Chattanooga	3	4	34	33	0	1	76	71
	Memphis	3	3	28	26	0	2	48	46
Tex:	Austin	3	3	8	8	0	1	31	29
	Dallas	3	3	18	18	0	1	44	42
Utah:	Salt Lake City	3	3	24	23	0	2	131	126
Vt:	Burlington	3	3	23	22	2	2	125	118
Va:	Norfolk	3	4	17	16	1	2	68	64
Wash:	Seattle	4	3	25	24	0	0	127	115
	Spokane	3	3	26	25	0	0	110	104
W. Va:	Charleston	3	4	20	19	1	2	49	45
Wis:	Milwaukee	3	3	15	15	2	3	96	90
Wyo:	Laramie	4	3	17	16	0	2	82	77
Network average		3	3	21	20	1	2	85	80

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <2 pCi/liter.
[b] Annual averages were computed on basis of 48 weekly averages.

results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous 12-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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[2] Beginning with the October 1963 data, iodine-131 values of <10 pCi/liter for individual samples are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

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RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES JANUARY-MARCH 1965

Division of Radiological Health Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially the program was conducted at eight institutions; as of January 1965, its scope had increased to 50 boarding schools or institutions, distributed as shown in figure 1. These institutions range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (with the exception of those at Los Angeles, California; Fargo, North Dakota; Columbia, Mississippi; and Carson City, Nevada) is located in a community from which the PHS Pasteurized Milk Network (PMN) collects samples. Special milk samples are collected from two institutions recently added to the network at Wrentham, Massachusetts, and Sioux Falls, South Dakota; these are not communities sampled by the PMN. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

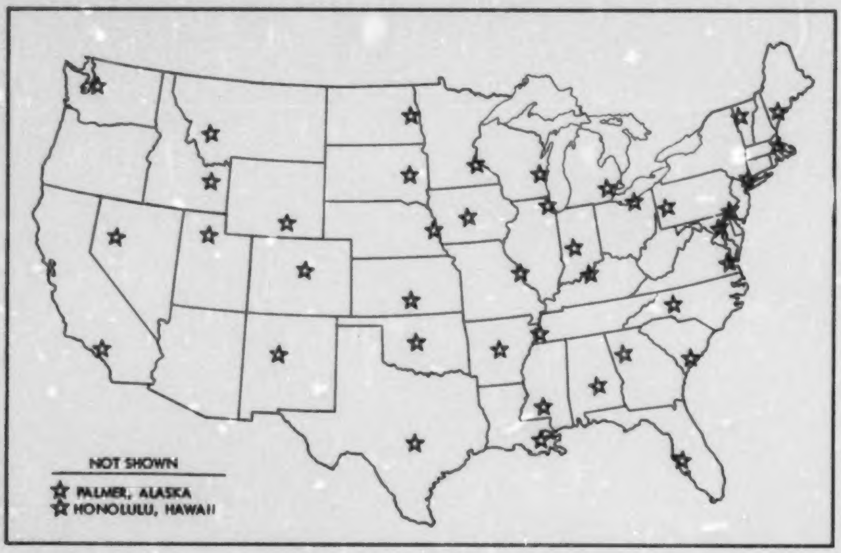

Figure 1. Institutional diet sampling locations

Table 1. Institutional diet analytical results, all schools, first quarter 1965

Location of institution		Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery	Jan	0.5	1.2	<5	11	45	NA
		Feb	0.6	1.2	<5	14	40	NA
		Mar	0.5	1.3	<5	11	45	NA
Alaska:	Palmer	Jan	0.6	1.5	<5	15	100	0.6
		Feb	0.4	1.1	<5	8	80	0.5
		Mar	0.5	1.4	<5	17	60	NA
Ariz:	Phoenix	Jan	0.7	1.7	<5	18	75	0.9
		Feb	0.8	1.9	<5	28	100	0.7
		Mar	0.7	1.5	<5	20	80	0.7
Ark:	Little Rock	Jan	0.7	1.2	<5	20	50	NA
		Feb	0.7	1.2	<5	20	45	NA
		Mar	0.6	1.5	<5	22	40	NA
Calif:	Los Angeles	Jan	0.5	1.6	<5	8	35	1.3
		Feb	0.8	1.9	<5	17	55	NA
		Mar	0.8	1.5	<5	13	20	0.7
Colo:	Denver	Jan	0.7	1.4	<5	18	35	0.6
		Feb	0.5	1.6	<5	20	45	0.6
		Mar	0.7	1.4	<5	19	40	0.8
Conn:	Hartford	Jan	0.7	1.7	<5	12	95	0.5
		Feb	0.7	1.7	<5	14	90	0.5
		Mar	0.6	1.6	<5	11	65	0.5
Del:	Wilmington	Jan	0.8	1.8	<5	12	60	0.6
		Feb	0.8	1.8	<5	12	80	1.0
		Mar	0.8	1.7	<5	14	80	0.5
Fla:	Tampa	Jan	0.7	1.4	<5	17	110	NA
		Feb	0.6	1.8	<5	8	105	NA
		Mar	0.8	1.4	<5	12	75	NA
Ga:	Atlanta	Jan	0.5	1.6	<5	10	65	NA
		Feb	0.7	1.9	<5	19	70	NA
		Mar	0.7	1.7	<5	19	70	NA
Hawaii:	Honolulu	Jan	0.5	1.2	<5	9	65	0.4
		Feb	0.4	1.0	<5	16	40	0.6
		Mar	0.5	1.0	<5	14	30	0.6
Idaho:	Idaho Falls	Jan	0.6	1.4	<5	16	80	0.5
		Feb	0.6	1.7	<5	36	140	0.4
		Mar	0.7	1.6	<5	25	125	0.6
Ill:	Chicago	Jan	0.8	1.6	<5	12	85	0.6
		Feb	0.8	1.5	<5	15	80	0.8
		Mar	0.8	1.6	<5	14	85	0.5
Ind:	Indianapolis	Jan	0.7	1.5	<5	11	60	0.4
		Feb	0.9	1.5	<5	14	70	0.5
		Mar	0.7	1.6	<5	11	70	0.6
Iowa:	Des Moines	Jan	0.7	1.8	<5	13	60	NA
		Feb	0.7	1.6	<5	13	60	NA
		Mar	0.7	1.6	<5	14	50	NA
Kans:	Wichita	Jan	0.7	1.6	20	15	45	NA
		Feb	0.8	1.8	<5	16	50	NA
		Mar	0.8	1.7	<5	16	50	NA
Ky:	Louisville	Jan	0.9	1.8	<5	19	50	NA
		Feb	0.7	1.5	<5	19	40	NA
		Mar	0.7	1.4	<5	16	35	NA
La:	New Orleans	Jan	0.6	1.4	<5	17	100	NA
		Feb	0.7	1.5	<5	13	55	NA
		Mar	0.7	1.5	<5	19	60	NA
Maine:	Portland	Jan	0.7	1.6	<5	17	100	0.5
		Feb	0.8	1.3	<5	13	85	0.6
		Mar	0.8	1.5	<5	17	95	0.5
Md:	Baltimore	Jan	0.6	1.2	<5	15	40	NA
		Feb	0.6	1.0	<5	14	50	NA
		Mar	0.6	1.4	<5	14	50	NA
Mass:	Boston A [a]	Jan	0.8	1.8	<5	19	115	0.5
		Feb	0.6	1.4	<5	12	80	0.4
		Mar	0.8	1.6	<5	18	105	0.7
	Boston B [a]	Jan	0.6	1.6	<5	11	60	0.7
		Feb	0.6	1.4	<5	10	40	0.6
		Mar	0.6	1.3	<5	10	50	0.4
Mich:	Detroit	Jan	0.8	1.7	<5	13	70	0.6
		Feb	0.8	1.5	<5	13	65	0.6
		Mar	0.8	1.6	<5	12	85	0.8
Minn:	Minneapolis	Jan	NS	NS	NS	NS	NS	NS
		Feb	0.7	1.6	<5	53	65	0.7
		Mar	0.8	1.7	<5	38	80	0.4
Miss:	Columbia	Jan	0.9	1.4	10	26	75	NA
		Feb	0.8	1.6	<5	18	70	NA
		Mar	0.8	1.4	<5	22	70	NA
Mo:	St. Louis	Jan	0.7	1.4	<5	38	45	1.4
		Feb	0.7	1.6	<5	22	55	0.6
		Mar	0.7	1.7	<5	27	85	0.6
Mont:	Helena	Jan	0.5	1.4	<5	14	70	0.7
		Feb	0.5	1.3	<5	21	70	0.4
		Mar	0.5	1.1	<5	16	60	0.4
Nebr:	Omaha	Jan	0.8	1.5	<5	19	35	0.8
		Feb	0.8	1.4	<5	25	55	NA
		Mar	0.8	1.8	<5	21	55	1.1
Nev:	Carson City	Jan	0.8	1.4	<5	11	40	1.1
		Feb	1.3	1.8	<5	46	40	1.6
		Mar	0.6	1.7	<5	25	40	0.6
N. J:	Trenton	Jan	0.7	1.4	<5	11	60	1.3
		Feb	0.7	1.5	<5	12	65	0.7
		Mar	0.5	1.5	<5	10	70	1.5
N. Mex:	Albuquerque	Jan	0.8	1.6	<5	9	25	0.7
		Feb	0.7	1.5	<5	13	35	0.7
		Mar	0.8	1.8	<5	10	30	0.9

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Table 1. Institutional diet analytical results, all schools, first quarter 1965—Continued

Location of institution		Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
N. Y:	New York	Jan	0.6	1.7	<5	14	90	0.8
		Feb	0.8	1.6	<5	16	70	1.0
		Mar	0.7	1.5	<5	12	65	1.0
N. C:	Charlotte	Jan	0.6	1.2	<5	14	50	NA
		Feb	0.6	1.2	<5	19	40	NA
		Mar	0.6	1.0	<5	14	35	NA
N. Dak:	Fargo	Jan	0.7	1.7	<5	25	95	0.5
		Feb	0.8	1.7	<5	11	70	0.5
		Mar	0.8	1.8	<5	13	65	1.2
Ohio:	Cleveland	Jan	0.8	1.7	<5	12	85	0.4
		Feb	0.7	1.7	<5	10	70	0.8
		Mar	0.7	1.6	<5	13	70	0.8
Okla:	Oklahoma City	Jan	0.8	1.7	<5	16	45	NA
		Feb	0.6	1.6	<5	11	35	NA
		Mar	0.7	1.7	<5	14	40	NA
Ore:	Portland	Jan	0.6	1.7	<5	16	30	0.9
		Feb	0.5	1.5	<5	24	45	0.5
		Mar	0.5	1.5	<5	10	40	0.6
Pa:	Pittsburgh	Jan	0.6	1.4	<5	15	70	0.5
		Feb	0.6	1.7	<5	19	75	0.8
		Mar	0.6	1.3	<5	15	60	0.7
R. I:	Providence	Jan	0.7	1.5	<5	15	80	0.5
		Feb	0.8	1.5	<5	12	75	0.5
		Mar	NS	NS	NS	NS	NS	NS
S. C:	Charleston	Jan	0.9	1.5	10	25	75	NA
		Feb	0.6	1.4	<5	14	60	NA
		Mar	0.7	1.5	<5	16	70	NA
S. Dak:	Sioux Falls	Jan	0.9	1.7	<5	19	95	0.7
		Feb	0.8	1.5	<5	22	75	0.7
		Mar	0.7	1.7	<5	13	85	0.7
Tenn:	Memphis	Jan	0.6	1.2	<5	16	40	NA
		Feb	0.6	1.5	<5	13	35	NA
		Mar	0.7	1.5	<5	14	40	NA
Tex:	Austin	Jan	0.4	1.1	<5	8	20	NA
		Feb	0.5	1.0	<5	8	30	NA
		Mar	0.5	1.2	<5	6	30	NA
Utah:	Salt Lake City	Jan	0.7	1.7	<5	9	75	0.5
		Feb	0.6	1.4	<5	14	60	0.4
		Mar	0.5	1.7	<5	16	65	0.6
Vt:	Burlington	Jan	0.6	1.7	<5	14	80	0.5
		Feb	0.6	1.7	<5	15	90	0.5
		Mar	0.6	1.7	<5	14	90	0.4
Va:	Norfolk	Jan	0.5	1.2	<5	17	45	NA
		Feb	0.5	1.1	<5	15	40	NA
		Mar	0.5	1.4	<5	14	40	NA
Wash:	Seattle	Jan	0.8	1.4	<5	36	105	0.5
		Feb	0.7	1.1	<5	18	70	1.3
		Mar	0.6	1.4	<5	20	80	0.6
W. Va:	Charleston	Jan	0.7	1.6	10	22	65	NA
		Feb	0.7	1.8	<5	17	70	NA
		Mar	0.8	1.9	<5	16	50	NA
Wis:	Milwaukee	Jan	0.5	1.7	<5	9	65	0.9
		Feb	0.7	1.6	<5	10	80	0.7
		Mar	0.7	1.5	<5	11	60	0.5
Wyo:	Laramie	Jan	0.7	2.0	<5	12	65	1.9
		Feb	0.8	1.4	<5	16	45	0.9
		Mar	0.7	1.5	<5	14	55	0.7
Institutional averages		Jan	0.7	1.5	<5	16	65	0.7
		Feb	0.7	1.5	<5	17	65	0.7
		Mar	0.7	1.5	<5	16	60	0.7

[a] "A" and "B" denote two separate institutions in Boston.
Key to symbols:
NA, no analysis.
NS, no samples.

Sampling procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vagas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The sample for each day is packaged in three parts: (1) solid food and semisolid food minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee, and tea. Drinking

Table 2. Institutional diet daily intakes, teenage boys, first quarter 1965

Location of institution	Age (yrs)	Month (1965)	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala: Montgomery	15–17	Jan	2.42	1.2	2.9	5	27	110	NA
	15–17	Feb	2.39	1.4	2.9	5	33	95	NA
	15–17	Mar	2.42	1.2	3.2	5	27	110	NA
Hawaii: Honolulu	14–16	Jan	1.40	0.7	1.7	5	13	90	0.6
	14–17	Feb	1.70	0.7	1.7	5	27	70	1.0
	15–19	Mar	1.87	0.9	1.9	5	26	55	1.1
Idaho: Idaho Falls	17	Jan	1.51	0.9	2.1	5	24	190	0.8
	15	Feb	2.04	1.2	3.5	5	73	285	0.8
	17	Mar	1.87	1.3	3.0	5	47	235	1.1
Iowa: Des Moines	14–16	Jan	2.06	1.9	4.8	5	55	160	NA
	15–16	Feb	3.15	2.2	5.1	10	41	190	NA
	15–16	Mar	2.90	2.0	4.6	5	41	145	NA
Ky: Louisville	15–17	Jan	2.40	2.2	4.4	5	47	125	NA
	15–16	Feb	1.51	1.3	2.7	5	34	70	NA
	15–17	Mar	2.14	1.5	3.0	5	34	75	NA
Maine: Portland	14	Jan	2.30	1.6	3.7	5	39	230	1.2
	14	Feb	2.39	1.9	3.1	5	31	205	1.4
	14	Mar	2.21	1.8	3.3	5	38	210	1.1
Minn: Minneapolis	NS	Jan	NS	NS	NS	NS	NS	NS	NS
	14–16	Feb	2.20	1.5	3.5	5	117	145	1.5
	14–15	Mar	2.12	1.7	3.6	5	51	170	0.8
Miss: Columbia	15–17	Jan	2.10	1.9	2.9	20	55	160	NA
	15–17	Feb	3.01	2.4	4.8	10	54	210	NA
	15–17	Mar	2.00	1.6	2.8	5	44	140	NA
Mo: St. Louis	15–17	Jan	1.22	0.8	1.7	5	46	55	1.7
	15–17	Feb	1.81	1.3	2.9	5	40	100	1.1
	15–17	Mar	2.52	1.8	4.3	5	68	200	1.5
Nebr: Omaha	15–18	Jan	1.50	1.2	2.2	5	28	50	1.2
	15–17	Feb	1.72	1.4	2.4	5	43	95	NA
	16–17	Mar	1.78	1.4	3.2	5	37	100	2.0
N. J: Trenton	15–17	Jan	2.31	1.6	3.2	5	25	140	3.0
	15–17	Feb	2.25	1.6	3.4	5	27	145	1.6
	15–17	Mar	2.40	1.2	3.6	5	24	170	3.6
Ore: Portland	14–17	Jan	1.31	0.8	2.2	5	21	40	1.2
	15–17	Feb	1.53	0.8	2.3	5	37	70	0.8
	15–17	Mar	2.27	1.1	3.4	5	23	90	1.4
Pa: Pittsburgh	14–16	Jan	2.27	1.4	3.2	5	34	160	1.1
	14–17	Feb	2.81	1.7	4.8	5	53	210	2.2
	15–17	Mar	2.53	1.5	3.3	5	38	150	1.8
R. I: Providence	13–15	Jan	2.49	1.7	3.7	5	37	200	1.2
	13–15	Feb	2.76	2.2	4.1	5	33	205	1.4
	NS	Mar	NS	NS	NS	NS	NS	NS	NS
Tex: Austin	14–17	Jan	2.08	0.8	2.3	5	17	40	NA
	15–17	Feb	1.89	0.9	1.9	5	15	55	NA
	15–16	Mar	1.83	0.9	2.2	5	11	55	NA
Va: Norfolk	15–16	Jan	2.28	1.1	2.7	5	39	105	NA
	15–16	Feb	2.24	1.1	2.5	5	34	90	NA
	15–16	Mar	2.35	1.2	3.3	5	33	95	NA
Wis: Milwaukee	15–17	Jan	2.21	1.1	3.8	5	20	145	2.0
	15–18	Feb	2.23	1.6	3.6	5	22	180	1.6
	14–15	Mar	1.94	1.4	2.9	5	21	115	1.0
Institutional averages for teenage boys, 13–18 years.		Jan	2.03	1.3	13.0	5	32	120	1.4
		Feb	2.23	1.5	3.2	5	42	140	1.3
		Mar	2.20	1.4	3.2	5	37	130	1.5

Key to symbols: NA, no analysis.
NS, no sample.

water is neither included in these samples nor reported. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample.

Analytical procedures

Because calcium compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program. Total weight is accurately determined in the laboratory. Stable calcium determinations are obtained by conventional gravimetric or spectrophotometric methods. Sample volumes usually range from 6 to 16 liters; sample weights range from 8 to 20 kilograms.

Results

Table 1 gives the analytical results for institutional diet samples collected from January through March 1965. Stable elements are reported in g/kg of diet, and radionuclide concentrations are expressed as pCi/kg of diet. A maximum of 50 institutions participated in this sampling program during this period.

When discussing intake on a daily basis it is meaningful to delineate differences resulting from age and sex. In an effort to evaluate these differences, table 2 presents the dietary intake of teen-age boys on a daily basis. The intake values were obtained by multiplying the food consumption rate in kg/day times the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine-131 and barium-140 were interpreted as zero and "less than" 5 pCi/kg of strontium-89 as 2.5 pCi/kg.

Table 3 presents the daily dietary intake of teen-age girls. Table 4 presents the daily dietary intake of children 9 to 12 years of age.

A summary of these results, table 5, shows a variation between age groups. Teenage girls and younger children have comparable intakes while teen-age boys consistently have about a 20 percent higher intake. These values are comparable with the network average of 1.90 kg/day observed from 1961-1964 (*3*).

Where strontium-89 dietary intake remained below detectable levels, the strontium-90 dietary intake during this period remained fairly constant at approximately 27 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (*4*), indicating that quantitative surveillance and routine control are recommended.

Cesium-137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*3*). During this period, both barium-140 and iodine-131 concentrations were below detectable levels.

Table 3. Institutional diet daily intakes, teenage girls, first quarter 1965

Location of institution		Age (yrs)	Month (1965)	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Conn:	Hartford	15-16	Jan	1.89	1.3	3.2	5	23	180	0.9
		15-16	Feb	1.56	1.1	2.7	5	22	140	0.8
		14-17	Mar	1.82	1.1	2.9	5	20	120	0.9
Ga:	Atlanta	15-17	Jan [a]	1.67	0.8	2.7	5	27	110	NA
		15-17	Feb [a]	1.90	1.3	3.6	5	36	135	NA
		12-17	Mar	1.65	1.2	2.8	5	31	115	NA
La:	New Orleans	15-17	Jan	2.62	1.6	3.7	5	45	260	NA
		15-17	Feb	2.55	1.8	3.8	5	33	140	NA
		14-17	Mar	2.58	1.8	3.9	5	49	155	NA
Mont:	Helena	16	Jan	1.13	0.6	1.6	5	16	80	0.8
		15-16	Feb	1.68	0.8	2.2	5	35	120	0.7
		15-17	Mar	1.60	0.8	1.8	5	26	95	0.6
N. Y:	New York City	14-16	Jan	2.18	1.3	3.7	5	31	195	1.7
		10	Feb [b]	2.33	1.9	3.7	5	37	165	2.3
		11-14	Mar	2.34	1.6	3.5	5	28	150	2.3
N. C:	Charlotte	16-18	Jan	1.65	1.0	2.0	5	23	80	NA
		15-18	Feb	1.47	0.9	1.8	5	28	60	NA
		15-17	Mar	1.43	0.9	1.4	5	20	50	NA
Tenn:	Memphis	15-16	Jan	1.27	0.8	1.5	5	20	50	NA
		15-18	Feb	1.51	0.9	2.3	5	20	55	NA
		15-17	Mar	1.48	1.0	2.2	5	21	60	NA
Utah:	Salt Lake City	16	Jan	1.12	0.8	1.9	5	10	85	0.6
		15-17	Feb	1.36	0.8	1.9	5	19	80	0.5
		15-16	Mar	1.35	0.7	2.3	5	22	90	0.8
Wash:	Seattle	15-16	Jan	1.43	1.1	2.0	5	51	150	0.7
		15-17	Feb	1.98	1.4	2.2	5	36	140	2.6
		14-17	Mar	1.95	1.2	2.7	5	39	155	1.2
Institutional averages for teenage girls 13-18 years.			Jan	1.66	1.1	2.4	5	27	135	0.9
			Feb	1.73	1.1	2.4	5	28	105	1.2
			Mar	1.80	1.1	2.6	5	28	110	1.2

[a] Data for this month were not used in average because food samples were collected from boys as well as girls.
[b] Data for this month were not used in average because food samples were collected from two or more children who were less than 13 years of age.
NA, no analysis.

Table 4. Institutional diet daily intakes, children (9–12 years), first quarter 1965

Location of institution	Age (yrs)	Month (1965)	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	10–12	Jan	1.48	0.9	2.1	5	19	145	0.9
	10–12	Feb	1.44	0.6	1.6	5	12	115	0.7
	10–12	Mar	1.33	0.7	1.9	5	23	80	NA
Ariz: Phoenix	13–14	Jan [a]	1.26	0.9	2.1	5	23	95	1.1
	11	Feb	1.27	1.0	2.4	5	35	125	0.9
	12–13	Mar [a]	1.21	0.8	1.8	5	24	95	0.8
Ark: Little Rock	11–12	Jan	1.81	1.3	2.2	5	36	90	NA
	10–12	Feb	1.97	1.4	2.4	5	39	90	NA
	10–12	Mar	2.02	1.2	3.0	5	44	80	NA
Calif: Los Angeles	10–15	Jan	1.03	0.5	1.6	5	8	35	1.3
	11–13	Feb	1.24	1.0	2.4	5	21	70	NA
	11–13	Mar	1.79	1.4	2.7	5	23	35	1.3
Colo: Denver	10–12	Jan	1.94	1.4	2.7	5	25	70	1.2
	11–12	Feb	1.59	0.8	2.5	5	32	70	1.0
	10–12	Mar	2.56	1.8	3.6	5	49	100	2.0
Del: Wilmington	11–12	Jan	1.86	1.5	3.3	5	22	110	1.1
	11–13	Feb	1.97	1.6	3.5	5	24	100	2.0
	11–12	Mar	1.93	1.5	3.3	5	27	155	1.0
Fla: Tampa	11–13	Jan	2.06	1.4	2.9	5	35	225	NA
	11–13	Feb	2.36	1.4	4.2	5	19	250	NA
	10–17	Mar [a]	2.49	2.0	3.5	5	30	105	NA
Ill: Chicago	10–12	Jan	1.62	1.3	2.6	5	19	140	1.0
	10–12	Feb	1.19	1.0	1.8	5	18	95	1.0
	10–12	Mar	1.68	1.3	2.7	5	24	145	0.8
Ind: Indianapolis	10–12	Jan	1.77	1.2	2.7	5	19	105	0.7
	10–11	Feb	1.70	1.5	2.6	5	24	120	0.8
	10–12	Mar	1.57	1.1	2.5	5	17	110	0.9
Kans: Wichita	10	Jan	2.27	1.6	3.6	45	34	100	NA
	10–12	Feb	1.94	1.6	3.5	5	31	95	NA
	10–12	Mar	1.96	1.6	3.3	5	31	100	NA
Md: Baltimore	11–12	Jan	2.08	1.2	2.5	5	31	85	NA
	11–12	Feb	1.85	1.1	1.8	5	26	90	NA
	11–12	Mar	1.63	1.0	2.3	5	23	80	NA
Mass: Boston A [b]	10–12	Jan	1.76	1.4	3.2	5	33	200	0.9
	10–12	Feb	2.47	1.5	3.5	5	30	200	1.0
	10–12	Mar	1.78	1.4	2.8	5	32	185	1.2
Mass: Boston B [b]	10–12	Jan	2.49	1.5	4.0	5	27	150	1.7
	9–12	Feb	2.56	1.5	3.6	5	26	100	1.5
	10–12	Mar	2.54	1.5	3.3	5	25	125	1.0
Mich: Detroit	11–12	Jan	1.74	1.4	3.0	5	23	120	1.0
	10–12	Feb	1.76	1.4	2.6	5	23	115	1.1
	10–12	Mar	2.04	1.6	3.3	5	24	175	1.6
Nev: Carson City	10–12	Jan	1.32	1.1	1.8	5	15	55	1.5
	10–12	Feb	1.37	1.8	2.5	5	63	55	2.2
	10–12	Mar	1.33	0.8	2.3	5	33	55	0.8
N. Mex: Albuquerque	10–12	Jan	1.69	1.4	2.7	5	15	40	1.2
	10–12	Feb	2.03	1.4	3.0	5	26	70	1.4
	10–12	Mar	2.24	1.8	4.0	5	22	65	2.0
N. Dak: Fargo	9–12	Jan	1.25	0.9	2.1	5	19	120	0.6
	10–12	Feb	1.39	1.1	2.4	5	15	95	0.7
	10–11	Mar	1.33	1.1	2.4	5	17	85	1.6
Ohio: Cleveland	10–11	Jan	1.81	1.4	3.1	5	22	155	0.7
	10–11	Feb	1.61	1.1	2.7	5	16	115	1.3
	10–12	Mar	1.62	1.1	2.6	5	21	115	1.3
Okla: Oklahoma City	11–12	Jan	1.68	1.3	2.9	5	27	75	NA
	10–12	Feb	1.54	0.9	2.5	5	17	55	NA
	11–14	Mar	1.66	1.2	2.8	5	23	65	NA
S. C: Charleston	11	Jan	2.56	2.3	3.8	25	64	190	NA
	11	Feb	2.07	1.2	2.9	5	29	125	NA
	11	Mar	1.13	0.8	1.7	5	18	80	NA
S. Dak: Sioux Falls	10–12	Jan	1.65	1.5	2.8	5	31	155	1.2
	10–11	Feb	1.77	1.4	2.7	5	39	135	1.2
	9–11	Mar	1.90	1.3	3.2	5	25	160	1.3
Vt: Burlington	10–12	Jan	1.53	0.9	2.6	5	21	120	0.8
	11–12	Feb	1.46	0.9	2.5	5	22	130	0.7
	10–11	Mar	1.38	0.8	2.3	5	19	125	0.6
W. Va: Charleston	10–12	Jan	1.73	1.2	2.8	15	38	110	NA
	10–12	Feb	1.90	1.3	3.4	5	32	135	NA
	10–11	Mar	1.78	1.4	3.4	5	28	90	NA
Wyo: Laramie	11	Jan	1.44	1.0	2.9	5	17	95	2.7
	11	Feb	1.20	1.0	1.7	5	19	55	1.1
	11	Mar	1.77	1.2	2.7	5	25	95	1.2
Institutional averages for children, 9–12 years.		Jan	1.76	1.3	2.8	5	27	115	1.2
		Feb	1.74	1.2	2.7	5	27	110	1.2
		Mar	1.77	1.3	2.8	5	26	105	1.2

[a] Data for this month were not used to obtain average for younger school children since school had included food samples for two or more children aged 13 years or more.

[b] "A" and "B" denote two separate institutions in Boston.

NA, no analysis.

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Table 5. Summary of ITDSN intakes for January through March, 1965

Sampling groups	Month	No. of institutions	Weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day					
				Calcium	Potassium	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140	Radium-226
Teenage boys	Jan	16	2.03	1.3	3.0	5	32	0	120	0	1.4
	Feb	17	2.23	1.5	3.2	5	42	0	140	0	1.3
	Mar	16	2.20	1.5	3.2	5	37	0	130	0	1.5
Teenage girls	Jan	8	1.66	1.1	2.4	5	27	0	ᵃ135	0	0.9
	Feb	7	1.73	1.1	2.4	5	28	0	105	0	1.2
	Mar	9	1.80	1.1	2.6	5	28	0	110	0	1.2
Children	Jan	24	1.76	1.3	2.8	5	27	0	115	0	1.2
	Feb	24	1.74	1.2	2.7	5	27	0	110	0	1.2
	Mar	24	1.77	1.3	2.8	5	26	0	105	0	1.2

ᵃ Includes New Orleans, La., and Seattle, Wash., which had high cesium-137 concentrations relative to other stations.

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Recent coverage in *Radiological Health Data:*

Period	Issue
July–September 1963	*March 1964*
October–December 1963	*July 1964*
January–March 1964	*October 1964*
April–June 1964	*January 1965*
July–September 1964	*April 1965*
October–December 1964	*July 1965*

Section III—Water

GROSS RADIOACTIVITY, APRIL 1965, AND STRONTIUM-90, OCTOBER 1964–MARCH 1965, IN SURFACE WATERS OF THE UNITED STATES

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–8*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term increases in radioactivity from current or recent nuclear tests or events.

Normally, samples are counted within 2 weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on the recount are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (9). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents the most recent results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative locations, the first station listed being closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity.

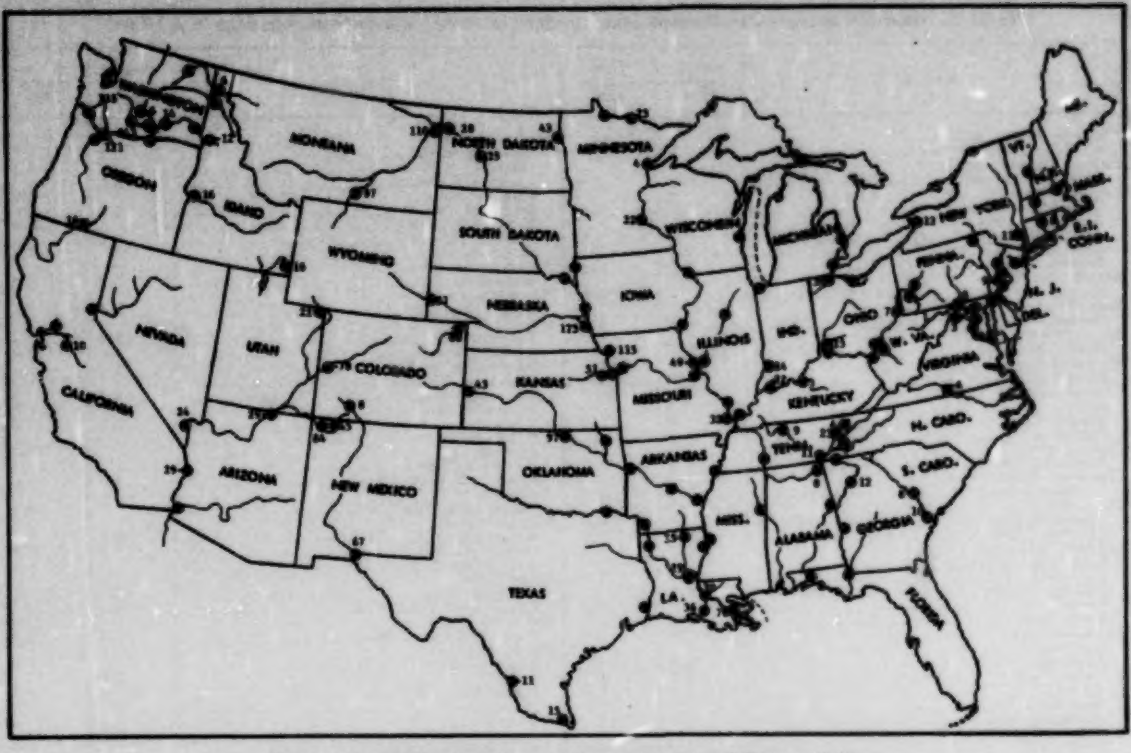
Strontium–90 determinations and results

Beginning in 1959, strontium–90 analyses of the total solids in surface waters were made quarterly on 3-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except at those stations immediately below nuclear installations, where regular quarterly analyses were continued. The method used for determining strontium–90 is a modification of a procedure described by Harley (*10*). The yttrium–90 together with yttrium carrier is precipitated as yttrium oxalate and the latter is washed, dried, weighted, and

Table 1. Radioactivity in raw surface waters, April 1965

(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	35	10	45	7	2	9
Arkansas River:						
Coolidge, Kans	15	28	43	5	29	34
Ponca City, Okla	74	23	97	14	1	15
Atchafalaya River:						
Morgan City, La	27	9	36	8	1	9
Bear River:						
Preston, Idaho	1	15	16	0	3	3
Big Horn River:						
Hardin, Mont	74	23	97	6	3	9
Chattahoochee River:						
Atlanta, Ga	8	4	12	3	0	3
Chena River:						
Fairbanks, Alaska	2	7	9	0	1	1
Clearwater River:						
Lewiston, Idaho	12	4	16	2	0	2
Clinch River:						
Clinton, Tenn	0	4	4	0	0	0
Kingston, Tenn	1	22	23	0	1	1
Colorado River:						
Loma, Colo	60	18	78	6	3	9
Page, Ariz	1	28	29	0	7	7
Boulder City, Nev	0	24	24	0	10	10
Parker Dam, Calif-Ariz	1	17	18	0	7	7
Columbia River:						
Wenatchee, Wash	0	6	6	0	1	1
Pasco, Wash	104	439	543	0	1	1
Bonneville, Oreg	38	83	121	0	1	1
Clatskanie, Ore	30	105	135	1	0	1
Connecticut River:						
Enfield Dam, Conn	3	5	8	0	0	0
Coosa River:						
Rome, Ga	4	4	8	1	0	1
Cumberland River:						
Cheatham Lock, Tenn	4	5	9	1	0	1
Delaware River:						
Philadelphia, Pa	3	6	9	1	0	1
Great Lakes:						
Duluth, Minn	1	3	4	0	0	0
Buffalo, N. Y	1	11	12	0	1	1
Green River:						
Dutch John, Utah	1	21	22	0	5	5
Hudson River:						
Poughkeepsie, N.Y	3	8	11	0	0	0
Kansas River:						
De Soto, Kans	35	16	51	6	2	8
Klamath River:						
Keno, Oreg	2	14	16	0	1	1
Maumee River:						
Toledo, Ohio	15	15	30	2	0	2
Mississippi River:						
St. Paul, Minn	3	19	22	0	0	0
E. St. Louis, Ill	34	15	49	6	0	6
Cape Girardeau, Mo	13	19	32	1	2	3
New Roads, La	20	10	30	5	1	6
New Orleans, La	65	11	76	40	1	41
Missouri River:						
Williston, N. Dak	10	18	28	2	3	5
Bismarck, N. Dak	17	18	35	4	4	8
St. Joseph, Mo	94	21	115	24	4	28
North Platte River:						
Henry, Nebr	2	35	37	0	32	32
Ohio River:						
Toronto, Ohio	2	5	7	<1	0	<1
Addison, Ohio	9	6	15	2	0	2
Cairo, Ill	13	9	22	4	0	4
Ouachita River:						
Bastrop, La	2	13	15	0	1	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	5	6	<1	<1	<1
Platte River:						
Plattsmouth, Nebr	153	22	175	42	5	47
Potomac River:						
Washington, D.C	0	3	3	0	0	0
Rainy River:						
Baudette, Minn	5	18	23	<1	<1	<1
Red River, North:						
Grand Forks, N. Dak	11	32	43	1	2	3
Red River, South:						
Alexandria, La	16	13	29	4	0	4
Rio Grande:						
Alamosa, Colo	1	7	8	1	1	2
El Paso, Tex	42	25	67	5	1	6
Laredo, Tex	2	9	11	0	4	4
Brownsville, Tex	4	11	15	1	4	5
San Joaquin River:						
Vernalis, Calif	3	7	10	1	1	2
San Juan River:						
Shiprock, N. Mex	71	13	84	22	4	26
Savannah River:						
Port Wentworth, Ga	2	8	10	0	0	0
Shenandoah River:						
Berryville, Va	2	4	6	0	0	0
Ship Creek:						
Anchorage, Alaska	1	1	2	0	0	0
Snake River:						
Payette, Idaho	4	8	12	1	2	3
Wawawai, Wash	8	6	14	1	1	2
South Platte River:						
Julesburg, Colo	6	54	60	1	42	43
Susquehanna River:						
Conowingo, Md	1	4	5	0	0	0
Tennessee River:						
Chattanooga, Tenn	3	8	11	0	0	0
Bridgeport, Ala	1	7	8	0	1	1
Wabash River:						
New Harmony, Ind	10	14	24	2	1	3
Yellowstone River:						
Sidney, Mont	88	22	110	25	5	30
Maximum	153	439	543	42	42	47
Minimum	0	1	2	0	0	0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NEW YORK
N. J.
DEL.
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MASS.
R.I.
CONN.

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, April 1965

counted in a low-background, anticoincidence, end-window proportional counter.

Table 2 presents the results of quarterly analyses of strontium-90 concentrations in U.S. surface waters for the fourth quarter of 1964 and the first quarter of 1965. Floyd and Weaver summarized the strontium-90 results obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*11*). The stations are arranged in the table according to their relative locations on the river, the first station being closest to the headwaters.

Discussion of results

The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*12*). The Public Health Service Drinking Water Standards state that in the absence of alpha emitters and strontium-90, a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*13*).[1] In table 1, the following stations show relatively high values for alpha and beta radioactivity because of parallel high suspended solids: Missouri River—St. Joseph, Missouri; Platte River—Plattsmouth, Nebraska; and Yellowstone River—Sidney, Montana. Other stations showing high levels of alpha and beta activity were: Mississippi River—New Orleans, Louisiana, and San Juan River—Shiprock, New Mexico.

While there are no standards for strontium-90 activity of total solids in surface waters, the Public Health Service Drinking Water Standards set the limit for strontium-90 concentrations in drinking water at 10 pCi/liter (*13*). During the fourth quarter of 1964, and the first quarter of 1965, this limit was not exceeded. Comparison between the two quarters is not feasible at all sampling locations due to fluctuations in sampling frequencies.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for alpha emitters and strontium-90, respectively.

Table 2. Quarterly average strontium-90 concentrations in surface waters (concentrations in pCi/liter)

Station	Fourth quarter 1964	First quarter 1965
Allegheny River:		
Pittsburgh, Pa	1.7	
Animas River:		
Cedar Hill, N. Mex		1.3
Arkansas River:		
Coolidge, Kans		0.4
Ponca City, Okla	2.9	
Fort Smith, Ark		3.8
Little Rock, Ark	2.9	
Pendleton Ferry, Ark	2.8	
Atchafalaya River:		
Morgan City, La		4.8
Bear River:		
Preston, Idaho		0.7
Big Horn River:		
Hardin, Mont	1.7	
Big Sioux River:		
Sioux Falls, S. Dak		1.9
Chattahoochee River:		
Lanett, Ala		0.9
Atlanta, Ga	1.0	
Columbus, Ga	1.2	
Chena River:		
Fairbanks, Alaska	0.1	
Clearwater River:		
Lewiston, Idaho		0.4
Clinch River:		
Clinton, Tenn		1.2
Kingston, Tenn	3.0	2.6
Colorado River:		
Loma, Colo	0.9	
Page, Ariz		3.9
Boulder City, Nev	1.7	
Parker Dam, Calif.-Ariz		1.0
Yuma, Ariz	1.2	
Columbia River:		
Northport, Wash		0.9
Wenatchee, Wash	1.8	
Pasco, Wash	2.2	1.9
McNary Dam, Ore	1.6	1.0
Bonneville, Ore		1.3
Clatskanie, Ore	1.0	
Connecticut River:		
Wilder, Vt		0.8
Northfield, Mass	1.3	
Enfield Dam, Conn		1.0
Coosa River:		
Rome, Ga		0.8
Cumberland River:		
Cheatham Lock, Tenn		1.0
Cuyahoga River:		
Cleveland, Ohio		2.5
Delaware River:		
Martins Creek, Pa	1.3	
Trenton, N. J		1.1
Philadelphia, Pa	1.2	
Escambia River:		
Century, Fla	0.9	
Great Lakes:		
Duluth, Minn	0.5	
Sault Ste. Marie, Mich		0.6
Milwaukee, Wis	0.8	
Gary, Ind		0.9
Port Huron, Mich	1.2	
Detroit, Mich		1.3
Buffalo, N. Y	2.3	
Green River:		
Dutch John, Utah		1.0
Hudson River:		
Poughkeepsie, N. Y	2.0	
Illinois River:		
Peoria, Ill	1.6	
Kanawha River:		
Winfield Dam, W. Va		0.7
Kansas River:		
De Soto, Kans	3.3	
Klamath River:		
Keno, Ore	1.5	
Little Miami River:		
Cincinnati, Ohio		2.2
Maumee River:		
Toledo, Ohio	2.1	
Merrimack River:		
Lowell, Mass		0.6
Mississippi River:		
St. Paul, Minn		3.1
Dubuque, Iowa	2.9	
Burlington, Iowa		2.6
E. St. Louis, Ill	2.7	
Cape Girardeau, Mo		3.2
W. Memphis, Ark	2.2	
Vicksburg, Miss		1.9
Delta, La	2.4	
New Roads, La	2.1	
New Orleans, La		1.7
Missouri River:		
Williston, N. Dak	2.1	
Bismarck, N. Dak		3.4
Yankton, S. Dak	3.3	
Omaha, Nebr		2.6
St. Joseph, Mo	3.0	
Kansas City, Kans		2.8
Missouri City, Mo	3.6	
St. Louis, Mo		2.4
Monongahela River:		
Pittsburgh, Pa	1.8	
North Platte River:		
Henry, Nebr	0.5	
Ohio River:		
Toronto, Ohio	2.0	
Addison, Ohio		0.9
Huntington, W. Va	1.4	
Cincinnati, Ohio		1.3
Louisville, Ky	2.1	
Evansville, Ind		1.5
Cairo, Ill	2.1	
Ouachita River:		
Bastrop, La		2.0
Pend Oreille River:		
Albeni Falls Dam, Idaho	1.0	
Platte River:		
Plattsmouth, Nebr		2.0
Potomac River:		
Williamsport, Md	0.8	
Great Falls, Md		0.9
Washington, D. C		1.1
Rainy River:		
Baudette, Minn	3.5	
International Falls, Minn	3.2	
Red River, North:		
Grand Forks, N. Dak	5.4	5.3
Red River, South:		
Denison, Tex		4.9
Index, Ark	3.4	
Bossier City, La		1.7
Alexandria, La	2.7	
Rio Grande:		
Alamosa, Colo	0.7	
El Paso, Tex		0.4
Laredo, Tex	1.7	
Brownsville, Tex		2.0
Roanoke River:		
John H. Kerr Resr/Dam, Va	1.5	
Sabine River:		
Ruliff, Tex		1.6
Sacramento River:		
Greens Landing, Calif		0.8
St. Lawrence River:		
Massena, N. Y		1.5
San Joaquin River:		
Vernalis, Calif	1.0	
San Juan River:		
Shiprock, N. Mex	2.1	
Savannah River:		
North Augusta, S. C		1.2
Port Wentworth, Ga	1.8	1.4
Schuylkill River:		
Philadelphia, Pa		1.5
Shenandoah River:		
Berryville, Va	0.5	
Ship Creek:		
Anchorage, Alaska		0.2
Snake River:		
Payette, Idaho	0.9	
Wawawai, Wash	0.6	
Ice Harbor Dam, Wash		0.5
South Platte River:		
Julesburg, Colo	0.7	
Spokane River:		
Post Falls Dam, Idaho		0.7
Susquehanna River:		
Sayre, Pa		0.7
Tennessee River:		
Lenoir City, Tenn	1.2	
Chattanooga, Tenn	1.3	1.2
Bridgeport, Ala	1.0	
Pickwick Landing, Tenn		1.2
Tombigbee River:		
Columbus, Miss		1.5
Truckee River:		
Farad, Calif	0.6	
Verdigris River:		
Nowata, Okla	3.0	
Wabash River:		
New Harmony, Ind	1.6	
Willamette River:		
Portland, Oreg	0.3	
Yakima River:		
Richland, Wash		0.4
Yellowstone River:		
Sidney, Mont		1.7

Comparison with results prior to October 1964 should take into consideration instrument recalibration which resulted in a lowering of strontium-90 values by 15 percent (*14*).

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[2] Single free copies of this publication may be obtained from Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

DRINKING WATER ANALYSIS PROGRAM, 1962[1]

Division of Environmental Engineering and Food Protection, and Division of Radiological Health, Public Health Service

The Drinking Water Analysis Program, initiated in November 1960, provides data on radioactivity levels in the water supplies of 139 municipalities. This program is conducted under the Public Health Service's Interstate Carrier Branch which is responsible for the certification of drinking water supplies used by Interstate Common Carriers.

Figure 1 shows the nationwide distribution of the 139 municipalities included in the second sampling, conducted during 1962. Where more than one source of drinking water exists in a municipality, each source is sampled.

The drinking water standards for radionuclides (*1*) are conservative in their requirements so that the total intake of these nuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (*2*).

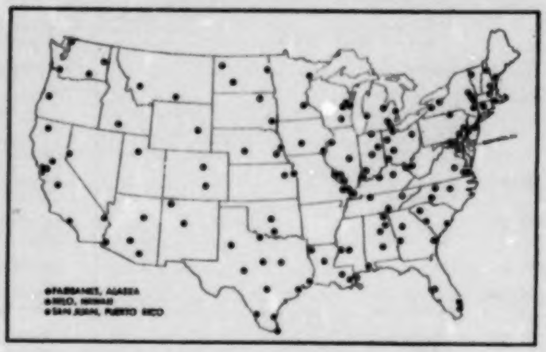

Figure 1. Drinking water analysis program sampling stations.

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[1] Summarized from "Drinking Water Quality of Selected Interstate Carrier Water Supplies, 1962-1963," U.S. Public Health Service, PHS Publication No. 1049-A.

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Table 1. Radioactivity concentration (pCi/liter) in drinking waters, December 1961–June 1963

Sampling location		Sampling periods a	Strontium-90 in total solids	Alpha activity		Beta activity	
State	City			Dissolved	Suspended	Dissolved	Suspended
Ala:	Birmingham						
	Shades Pl.	5/4-5/19	—	—	—	8.8	<3.0
	Putnam Pl.	5/2-5/18	—	—	—	5.2	<3.0
	Gadsden	3/14-3/28	—	—	—	14.0	<3.0
	Mobile	5/1-5/15	—	—	—	14.0	<3.0
Conn:	Hartford	12/5-12/18	<1.0	<1.0	<1.0	4.0	1.0
Del:	Wilmington						
	Porter FP	9/11-9/24	<1.0	<1.0	<1.0	3.0	<1.0
	Brandywine FP	10/2-10/15	<1.0	<1.0	<1.0	5.0	<1.0
Fla:	Ft. Lauderdale						
	Dixie Pl.	9/19-10/9	—	—	—	3.0	3.0
	Fiveash Pl.	9/19-10/3	—	—	—	<3.0	<3.0
	Miami						
	Hialeah Pl.	11/8-11/22	—	—	—	<3.0	<3.0
	Orr Pl.	11/8-11/22	—	—	—	<3.0	<3.0
	Tampa	9/18-10/3	—	—	—	10.0	<3.0
Ga:	Atlanta						
	Chattahoochee Pl.	3/13-3/29	—	—	—	7.9	<3.0
	Memphill Pl.	12/17-1/2/63	—	—	—	8.8	<3.0
	Columbus	1/10/63-1/28/63	—	—	—	11.8	<3.0
	Savannah						
	Ind.-Domestic Supply	8/2-8/16	—	—	—	5.9	3.0
	Well Supply	8/2-8/16	—	—	—	<3.0	<3.0
Ill:	Cairo	6/29-7/13	<1.0	<1.0	<1.0	<1.0	<1.0
Ind:	Elkhart	2/19-3/5	—	—	—	<3.0	<3.0
	Evansville	8/6-8/21	<1.0	<1.0	<1.0	4.0	<1.0
	Indianapolis						
	White River Pl.	5/16-5/30	—	—	—	12.1	<3.0
	Fall Creek Pl.	5/14-5/29	—	—	—	15.0	<3.0
	Muncie	5/24-6/7	—	—	—	19.0	<3.0
	Washington	8/6-8/20	<1.0	0.0	0.1	0.1	0.0
Iowa:	Burlington	1/4-1/18	—	1.0	—	9.3	0.3
Ky:	Paducah	3/7-3/21	—	—	—	22.0	<3.0
La:	Alexandria	10/24-11/14	—	—	—	5.1	<3.0
	Baton Rouge	9/20-10/[illegible]	—	—	—	9.4	3.0
	New Orleans	11/6-11/[illegible]	—	—	—	7.2	<3.0
	Shreveport						
	Cross Lake Pl.	9/20-10/[illegible]	—	—	—	<3.0	<3.0
	McNeill St. Pl.	9/21-10/8	—	—	—	8.8	<3.0
Maine:	Portland	10/10-10/26	<1.0	<1.0	<1.0	7.0	<1.0
Md:	Baltimore						
	Montebello Pl.	6/13/63-6/26/63	—	—	—	8.7	<3.0
	Hagerstown						
	Mountain Supply	5/14-5/29	—	—	—	5.8	<3.0
	Potomac River Station	5/15-5/28	—	—	—	10.0	<3.0
Mass:	Lowell	2/5/63-2/18/63	<1.0	<1.0	<1.0	3.0	<1.0
Mich:	Ann Arbor	9/10-10/3	<1.0	<1.0	<1.0	3.0	<1.0
	Bay City	4/4-4/20	2.4	—	—	16.0	<3.0
	Monroe	9/17-10/2	<1.0	<1.0	<1.0	3.0	<1.0
	Muskegon	4/6-4/23	<1.0	—	—	7.3	<3.0
	Port Huron	9/17-9/30	<1.0	<1.0	<1.0	4.0	2.0
Miss:	Greenville	10/25-11/9	—	—	—	<3.0	<3.0
	Vicksburg	8/13-8/28	—	—	—	11.4	<3.0
N. H:	Berlin	10/15-10/30	<1.0	<1.0	<1.0	6.0	<1.0
	Manchester	10/20-11/2	<1.0	<1.0	<1.0	8.0	1.0
N. J:	Trenton	10/10-10/25	<1.0	<1.0	<1.0	4.0	<1.0
N. Mex:	Albuquerque	8/2-8/17	—	—	—	<3.0	3.3
	Farmington	8/6-8/21	—	—	—	4.8	<3.0
N. Y:	Albany	3/27-4/9	2.0	—	—	14.0	<3.0
	Buffalo	9/4-9/18	<1.0	0.0	0.1	3.8	0.4
	New York City						
	Woodhaven W.S.	2/2-2/19	—	—	—	<3.0	<3.0
	Poughkeepsie	12/3-12/20	<1.0	<1.0	<1.0	8.0	<1.0
	Rochester						
	Lake Hemlock	8/29-9/12	<1.0	<1.0	<1.0	6.0	4.0
	Lake Ontario	8/30-9/13	<1.0	0.1	0.1	2.2	4.8
	Monroe Co. W. Authority	8/30-9/15	<1.0	<1.0	<1.0	1.0	<1.0
	Schenectady	3/22-4/5	—	—	—	<3.0	<3.0
	Troy	4/11-4/28	<1.0	—	—	18.0	4.0
N. C:	Raleigh	3/22-4/5	1.6	—	—	19.0	<3.0
Ohio:	Akron	2/19-3/4	—	—	—	15.0	<3.0
	Cincinnati	8/6-8/20	<1.0	<1.0	<1.0	5.0	<1.0
	Lima	8/6-8/20	<1.0	<1.0	<1.0	5.4	<1.0
	Springfield	8/6-8/20	<1.0	0.0	0.1	0.8	0.6
	Toledo	2/19-3/7	—	—	—	8.1	3.0

Table 1. Radioactivity concentration (pCi/liter) in drinking waters, December 1961–June 1963—Continued

Sampling location		Sampling periods ᵃ	Strontium-90 in total solids	Alpha activity		Beta activity	
State	City			Dissolved	Suspended	Dissolved	Suspended
Okla:	Oklahoma City						
	Lake Hefner	4/26–5/14	—	—	—	12.0	<3.0
	Lake Overholser	5/3–5/17	—	—	—	12.0	<3.0
Pa:	Allentown	11/28–12/12	<1.0	<1.0	<1.0	1.0	<1.0
	Lancaster						
	Conestoga Pl	1/7/63–1/22/63	<1.0	<1.0	<1.0	9.0	<1.0
	Philadelphia						
	Belmont Filters (SS–RS)	12/21/61–1/6	—	—	—	11.0	<3.0
	Queen Lane Pl	12/21/61–1/4	—	—	—	14.0	<3.0
	Belmont Filters (RS)	12/21/61–1/6	—	—	—	13.0	<3.0
	Torresdale Pl	12/21/61–1/4	—	—	—	11.0	<3.0
	Sayre	9/4–9/22	<1.0	<1.0	<1.0	3.0	<1.0
S. C:	Charleston	2/11/63–2/26/63				14.8	<1.0
	Greenville	2/17/63–2/22/63				9.6	3.2
S. Dak:	Sioux Falls	2/21–3/9	—	—	—	8.0	1.0
Tenn:	Chattanooga	1/25–2/2	—	—	—	14.0	<3.0
	Clarksville	2/3–2/18	—	—	—	8.4	<3.0
	Knoxville	2/6–2/20	—	—	—	7.8	<3.0
Tex:	Brownsville						
	Plant No. 1	3/9–3/23	—	—	—	5.3	<3.0
	Plant No. 2	3/9–3/23	—	—	—	8.6	<3.0
	Brownwood	1/15–1/31	—	—	—	11.1	<3.0
	Laredo	3/1–3/16	—	—	—	19.0	<3.0
	Port Arthur	6/14–6/18	—	—	—	35.0	<3.0
	San Angelo	5/25–6/9	—	—	—	16.0	<3.0
	San Antonio	12/13/61–12/24/61	—	—	—	16.0	<3.0
	Waco	5/30–6/14	—	—	—	21.0	<3.0
	Wichita Falls	5/29–6/13	—	—	—	15.0	<3.0
Vt:	Burlington	12/11–12/29	<1.0	<1.0	<1.0	5.0	1.0
Va:	Norfolk						
	Moores Bridge Pl	4/9–4/25	—	—	—	21.0	<3.0
	37th Street Pl	4/9–4/24	1.3	—	—	20.0	<3.0
	Portsmouth	3/1–3/17	—	—	—	5.1	<3.0
	Richmond	3/18/63–5/3/63	—	—	—	8.1	<1.0
W. Va:	Huntington	6/7–6/22	—	—	—	6.8	<3.0
Wis:	Green Bay	9/17–10/2	<1.0	<1.0	<1.0	3.0	<1.0
	Manitowoc	11/5–11/23	<1.0	<1.0	<1.0	2.0	<1.0
	Neenah	10/19–11/1	—	<1.0	<1.0	5.0	<1.0

ᵃ 1963 unless otherwise indicated.

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium–226 or 10 pCi/liter of strontium–90. In the absence of strontium–90 (much less than 10 pCi/liter), and in the absence of alpha emitters (much less than 3 pCi/liter), the water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources is within the guidance recommended by the Federal Radiation Council for control action. When mixtures of radionuclides are present, the proportion of each radionuclide to its maximum limit should be considered when evaluating the exposure.

The determinations performed on the selected carrier supplies are sanitary chemical analyses, carbon chloroform analyses, spectrographic examinations, certain quantitative chemical analyses, and radiochemical analyses. Each sample to be analyzed for radionuclides consists of a composite of three aliquots a day obtained over a 2-week period. The analyses for gross alpha activity and strontium–90 are performed at the Southeastern, Northeastern, and Southwestern Radiological Health Laboratories, operated by the Division of Radiological Health.

The sensitivity of the analytical method requires that results on some samples be reported as "less than" a stated value. In statistically

Table 2. Frequency distribution of radioactivity concentrations (pCi/liter) levels in drinking waters, 1962 (December 1961–June 1963).

Strontium-90 activity		Dissolved beta activity	
Range from 1.0—2.4 Arithmetic mean—1.1 Total number of supplies—34 Number of "less than" values—30		Range from 0.1—35.0 Arithmetic mean—8.9 Total number of supplies—96 Number of "less than" values—11	
Interval	Number of supplies	Interval	Number of supplies
		0.0-1.9	5
		2.0-2.9	2
		3.0-3.9	17
<1.0	30	4.0-4.9	5
1.2-1.4	1	5.0-5.9	11
1.5-1.7	1	6.0-6.9	3
1.8-2.0	1	7.0-7.9	5
2.1-2.3	0	8.0-8.9	11
2.4-2.6	1	9.0-9.9	4
2.7-2.9	0	10.0-10.9	2
>2.9	0	11.0-11.9	5
		12.0-12.9	3
		13.0-13.9	1
		14.0-14.9	6
		15.0-15.9	3
		>15.9	13

Suspended beta activity		Dissolved alpha activity		Suspended alpha activity	
Range from 0.0—4.8 Arithmetic mean—2.4 Total number of supplies—96 Number of "less than" values—78		Range from 0.0—1.0 Arithmetic mean—0.9 Total number of supplies—30 Number of "less than" values—25		Range from 0.1—1.0 Arithmetic mean—0.9 Total number of supplies—29 Number of "less than" values—25	
Interval	Number of supplies	Interval	Number of supplies	Interval	Number of supplies
0.0-0.9	4	0.0-0.4	4	0.0-0.4	4
1.0-1.9	26	0.5-0.9	0	0.5-0.9	0
2.0-2.9	1	1.0-1.4	26	1.0-1.4	25
3.0-3.9	64	>1.4	0	>1.4	0
>3.9	1				

Table 3. Frequency distribution of radioactivity concentration (pCi/liter) levels in drinking waters, 1961 (November 1960–February 1962)

Strontium-90 activity		Dissolved beta activity	
Range from 0.1 to 3.3 Arithmetic mean—1.0 Total number of supplies—27 Number of "less than" values—6		Range from 0.6 to 200.0 Arithmetic mean—[illegible] Total number of supplies—141 Number of "less than" values—58	
Interval	Number of supplies	Interval	Number of supplies
0.0-0.2	4	0.0-1.9	4
0.3-0.5	4	2.0-2.9	16
0.6-0.8	4	3.0-3.9	67
0.9-1.1	10	4.0-4.9	12
1.2-1.4	1	5.0-5.9	10
1.5-1.7	0	6.0-6.9	11
1.8-2.0	2	7.0-7.9	4
2.1-2.3	0	8.0-8.9	1
2.4-2.6	0	9.0-9.9	1
2.7-2.9	0	10.0-10.9	3
>2.9	2	11.0-11.9	2
		12.0-12.9	3
		13.0-13.9	1
		14.0-14.9	1
		15.0-15.9	1
		>15.9	4

Suspended beta activity		Dissolved alpha activity		Suspended alpha activity	
Range from 0.3 to 35.0 Arithmetic mean—3.0 Total number of supplies—120 Number of "less than" values—116		Range from 0.5—19.9 Arithmetic mean—1.5 Total number of supplies—80 Number of "less than" values—70		Range from 0.1—9.4 Arithmetic mean—0.7 Total number of supplies—66 Number of "less than" values—62	
Interval	Number of supplies	Interval	Number of supplies	Interval	Number of supplies
0.0-0.9	2	0.0-0.4	0	0.0-0.4	2
1.0-1.9	15	0.5-0.9	69	0.5-0.9	61
2.0-2.9	7	1.0-1.4	0	1.0-1.4	1
3.0-3.9	93	>1.4	11	>1.4	2
>3.9	3				

treating the data, the full "less than" value is used. The effect of this is to place an upper limit on the results, which is quite satisfactory for surveillance and control action.

Table 1 presents data from the 1962 sampling, which was conducted from December 1961 to June 1963. In table 2, the same data are arranged to facilitate rapid visual comprehension, and in table 3, the data from the 1961 sampling (conducted from November 1960 to February 1962), are similarly arranged (*3*, *4*). Each item is shown in terms of its nationwide frequency distribution, range and mean. Also presented are the total number of supplies which provide the data, and the number of "less than" (<) values.

REFERENCES

(*1*) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE. Federal Register Rules and Regulations, Title 42, Public Health Chapter 1, Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards: 2154–2155 (March 6, 1962).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961). Price 20 cents.

(*3*) PUBLIC HEALTH SERVICE. Radioactivity in drinking water, 1961. Rad Health Data 3:157–158 (May 1962): 254–255 (August 1962): 411–412 (October 1962); 4:37–39 (January 1963).

(*4*) PUBLIC HEALTH SERVICE. Drinking water quality of selected Interstate carrier water supplies, 1960–1961. PHS Publication 1049 (June 1963).

RADIOLOGICAL SURVEY OF THE LOWER COLUMBIA RIVER IN OREGON, AUGUST 1963–JULY 1964[1]

George L. Toombs[2]

The Lower Columbia River Radiological Survey in Oregon was initiated in June 1961, with routine sample collection and analyses beginning in January 1962. This Survey is jointly funded by the Oregon State Board of Health and the Division of Radiological Health, U.S. Public Health Service.[3] The major objective is to determine and monitor the distribution of radionuclides in environmental media in the lower Columbia River and along the Oregon seacoast.

Hanford Atomic Products Operation, the major source of the radionuclide contaminants observed, is located on the upper Columbia River at Richland, Washington (see figure 1) and consists of a 500-square-mile complex of nuclear reactors, fuel fabrication plants, chemical separation facilities, and research and development laboratories. The Hanford reactor cooling waters add radioactivity to the Columbia River at a rate of several thousand curies per day. Hanford conducts an extensive environmental radiation surveillance program with Vancouver, Washington, being the farthest downstream location where river water and biota are sampled monthly.

This Lower Columbia River Study extends on a monthly basis, the radiological surveillance in the Columbia River to its confluence with the Pacific Ocean at Astoria, Oregon, and along the Oregon seacoast. During the period 1961–1963 the University of Washington, Department of Radiation Biology, maintained a routine sampling program along the Oregon seacoast. Routine monthly surveillance in this area is now provided by this Lower Columbia River study.

In addition to the Hanford surveillance programs and this Lower Columbia River study, other surveillance and research programs, concerned with the ecological factors and fate of radioactivity originating from Hanford, are supported by the U.S. Atomic Energy Commission and the U.S. Public Health Service. The areas involved in these programs are the Columbia River itself and beyond its mouth as far as 500 miles into the Pacific Ocean. Agencies involved in these studies are the University of Washington, Oregon State University, Washington State Department of Health, U.S. Geological Survey, Army Corps of Engineers, and the Bureau of Commercial Fisheries.

The data obtained from this Lower Columbia River Study, the Hanford surveillance program along with data on radioactivity in Washington and U.S. Surface Waters, are published routinely in Radiological Health Data (1–4).

Sampling procedures

The following criteria were used in the selection of sampling locations: (1) availability of samples which could be used to describe the concentrations of the radionuclides present in the environment; (2) accessibility on a year-round basis, and (3) avoidance of needless duplication of the sampling efforts of similar programs.

Samples were obtained on a monthly basis from five regular Columbia River and Oregon seacoast locations. Sampling during prior periods at John Day Dam and Arlington was discontinued early in 1964 due to construction in those areas which caused significant changes in environmental conditions at the sampling locations. In addition to the monthly sampling, a comprehensive sampling survey was conducted during April 1964 along the Oregon seacoast extending southward to Yaquina Bay. The sampling stations in this survey were previously used during the period 1961–1963 for similar sampling by the University of Washington, Department of Radiation Biology.

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[1] Summarized from "Lower Columbia River Environmental Radiological Survey in Oregon, 1963–1964," Division of Sanitation and Engineering, Oregon State Board of Health.

[2] Mr. Toombs is Chief Radiochemist, Division of Sanitation and Engineering, Oregon State Board of Health.

[3] This work was performed by the Oregon State Board of Health under Contract No. SAph 76874 between the U.S. Public Health Service and the Oregon State Board of Health.

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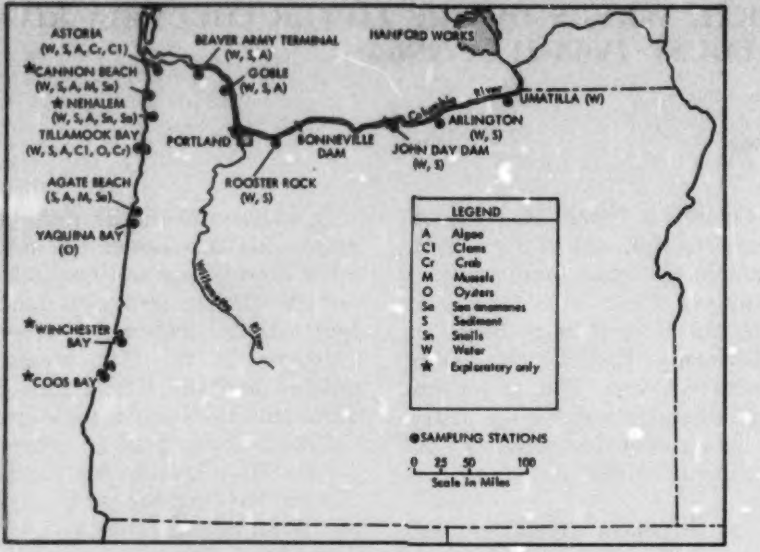
ASTORIA
(W, S, A, Cr, C1)
★CANNON BEACH
(W, S, A, M, Sa)
★ NEHALEM
(W, S, A, Sn, Sa)
TILLAMOOK BAY
(W, S, A, C1, O, Cr)
AGATE BEACH
(S, A, M, Sa)
YAQUINA BAY
(O)
★WINCHESTER BAY
★COOS BAY
BEAVER ARMY TERMINAL
(W, S, A)
GOBLE
(W, S, A)
PORTLAND
BONNEVILLE DAM
ROOSTER ROCK
(W, S)
HANFORD WORKS
Columbia River
UMATILLA (W)
ARLINGTON
(W, S)
JOHN DAY DAM
(W, S)
LEGEND
A Algae
C1 Clams
Cr Crab
M Mussels
O Oysters
Sa Sea anemones
S Sediment
Sn Snails
W Water
★ Exploratory only
● SAMPLING STATIONS
0 25 50 100
Scale in Miles

Figure 1. Columbia River study sampling locations

Water samples were collected in two-liter polyethylene bottles, as far out from the shore as was practical. Two milliliters of concentrated hydrochloric acid were added to each sample to prevent plating of the radionuclides onto the container surfaces and to keep dissolved substances in solution. Sediment samples were collected by scooping up approximately one liter of the top inch of deposits. Sediment and algae samples were collected from the shallow water along the shoreline, except at Tillamook Bay, where samples were collected on a mud flat which was accessible at low tide. Crab and oyster samples were obtained by purchase from local producers while all other shellfish were hand-gathered.

Analytical procedures

Samples were routinely analyzed utilizing gamma spectrometry, within one week after collection. Water, sediment, and algae samples were gamma-scanned in their original state. Shellfish samples were counted with the shell removed and included all soft parts and body liquids, but excluded mantle liquid. The edible portions of the crab, clam, and oyster samples were counted with normal tissue liquid. The usual counting periods were 100 minutes; however, some low-activity samples were counted as long as 800 minutes to achieve good counting statistics. All radionuclide concentrations were extrapolated to the date of collection.

Calibration and counting efficiencies for the gamma spectrometer system were determined by the use of standard liquid radionuclide sources. To eliminate the contribution to a given photopeak from higher-energy interfering radionuclides, Compton scatter corrections were calculated using the data from the standard radionuclide spectra. By approximating the portion of the count rate in the photopeak caused by Compton scattering due to the activity of the higher-energy radionuclide, corrections were made for this interference. Interference from higher-energy radionuclides not in the analysis scheme was not compensated for in the calculations and, if present, would cause the radionuclide concentrations reported to be somewhat higher than the true value.

For determining the gross alpha and gross beta activity of water, a 500-ml aliquot of a sample previously gamma-scanned was evaporated to dryness on a 2-inch planchet and counted in a gas-flow internal proportional counter utilizing a two-inch detector. The minimum detectable gross beta activity is approximately 10 pCi/liter; the limit for gross alpha analyses is less than 1 pCi/liter. The gross alpha and beta results are not corrected for decay since the concentrations of specific alpha- and beta-emitting radionuclides were not known. Due to the high concentrations of dis-

Table 1. Summary of radioactivity in water samples, Columbia River study

(Concentrations in pCi/liter)

Location and number of samples	Value	Gross Beta		^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	^{103}Ru+ ^{106}Ru	^{51}Cr
		Suspended	Dissolved					
Umatilla (1)		23	158	<170	86	<13	15	11,000
Arlington (3)	Min.	<10	115	<170	<35	<13	<10	8,400
	Ave.	12	151	134	105	<13	12	9,146
	Max.	19	215	233	157	<13	15	9,600
John Day Dam (2)	Min.	<10	115	<170	<35	<13	<10	5,800
	Ave.	<10	135	<170	<35	<13	<10	8,050
	Max.	11	155	<170	<35	<13	<10	10,300
Rooster Rock (14)	Min.	<10	15	<170	<35	<13	<10	1,175
	Ave.	14	63	<170	42	<13	<10	3,438
	Max.	34	205	267	75	<13	13	5,760
Goble (12)	Min.	<10	<10	<170	<35	<13	<10	800
	Ave.	12	54	<170	<35	<13	<10	2,078
	Max.	34	141	238	43	15	<10	3,550
Beaver Army Terminal (12)	Min.	<10	13	<170	<35	<13	<10	1,029
	Ave.	15	53	<170	35	<13	<10	2,439
	Max.	51	84	<170	81	<13	<10	4,670
Astoria (12)	Min.	<10	22	<170	<35	<13	<10	600
	Ave.	<10	[a] 48	<170	<35	<13	<10	1,614
	Max.	27	380	175	37	<13	16	2,480
Ft. Stevens (1)		<10		184	<35	<13	<10	<100
Tillamook Bay (11)	Min.		800	<170	<35	<13	<10	<170
	Ave.		[b] 810	<170	<35	<13	<10	<170
	Max.		820	284	<35	<13	<10	408

[a] Saltwater samples not included in average.
[b] Average of 2 samples.

solved solids, sea water samples were omitted from the alpha and beta analyses.

Results

The gross alpha activity for all water samples collected between August 1963 and July 1964 was below the minimum detectable concentration of 1 pCi/liter. The gross beta activity concentrations in the Columbia River water samples are summarized in table 1. In general, the concentrations were observed to decrease with increasing distance from the Hanford reactors (see figure 2). In addition, the data tended to confirm the expected decrease in concentrations during the summer months because of high dilution as the result of the increased summer flows in the Columbia River. All concentrations were below the maximum permissible concentrations recommended by the International Commission on Radiological Protection (*5*). For water from all dietary sources, the following ICRP standards are given for the population at large: ^{65}Zn, 10,000 pCi/liter; ^{95}Zr–^{95}Nb, 20,000 pCi/liter; ^{103}Ru, 27,000 pCi/liter; and ^{51}Cr, 670,000 pCi/liter.

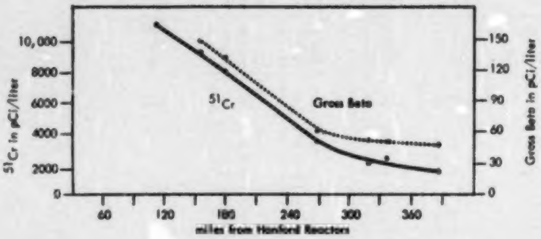

Figure 2. Average gross beta and chromium-51 concentrations in Columbia River water, August 1963–July 1964

Columbia River bottom sediments were found to contain comparatively high levels of radioactivity (table 2). Since radionuclide concentrations are dependent upon the characteristics of the sediment, the sediments collected were arbitrarily classified into different types and numbered 2 to 5, fine to coarse for aiding in the intercomparison of data.

The neutron activation radionuclide zinc-65 was observed in readily detectable concentrations in the biological samples collected: algae (table 3), and shellfish (table 4) shown in figures 3 to 6. Although these data represent significant concentrations of zinc-65, the amount consumed by the general public resulting from eating these shellfish would be far below the maximum permissible intake. Use of the guides, recommended by the International Committee on Radiation Protection for total body exposure for the general population, implies a permissible intake rate of 8 x 10^6 pCi/year for zinc-65. Considering the average concentration of zinc-65 in crab and oysters during this period (15 pCi/gram), the permissible intake

Table 2. Summary of radioactivity in sediment samples, Columbia River study

(Concentrations in pCi/gram wet or drained weight)

Location	Number of Samples	Usual sed. type	Value	^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	^{103}Ru+ ^{106}Ru
John Day Dam	2		Min.	15.8	2.5	0.4	<0.1
			Ave.	16.0	4.6	0.5	0.3
			Max.	16.2	6.7	0.6	0.5
Arlington	2	5	Min.	28.9	28.3	1.3	1.4
			Ave.	31.0	31.4	1.8	1.6
			Max.	33.0	34.5	2.2	1.7
Rooster Rock	13	5	Min.	12.9	0.9	0.2	0.2
			Ave.	15.6	11.2	1.4	0.6
			Max.	20.8	36.0	8.1	1.4
Goble	12	5	Min.	12.8	1.2	0.3	0.2
			Ave.	21.1	22.4	2.0	1.0
			Max.	54.5	99.6	6.7	3.9
Beaver Army Terminal	10	5	Min.	11.3	3.4	0.4	0.3
			Ave.	19.2	22.2	2.0	1.4
			Max.	41.1	128.0	8.2	7.7
Astoria	8	3	Min.	9.8	1.5	0.5	0.7
			Ave.	16.2	19.6	4.2	1.6
			Max.	25.0	42.3	11.0	3.6
Ft. Stevens	1		Min. Ave. Max.	10.8	0.3	0.3	0.1
Tillamook Bay	9	3	Min.	9.0	0.1	0.3	0.2
			Ave.	11.2	0.3	2.1	0.8
			Max.	13.3	0.6	6.1	2.1

Table 3. Summary of radioactivity in algae samples, Columbia River study

(Concentrations in pCi/gram wet or drained weight)

Location	Algae type	Number of samples	Value	^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	^{103}Ru+ ^{106}Ru	^{51}Cr [a]
Goble	*Cladophora* species	10	Min.	25.5	22.3	<0.17	0.2	710
			Ave.	43.3	88.2	6.9	4.2	1,230
			Max.	89.2	160.5	17.4	10.4	1,680
Goble	Green attached moss	2	Min.	39.4	93.4	1.1	2.2	
			Ave.	40.9	106.8	4.6	4.1	
			Max.	42.4	120.1	8.0	6.0	
Beaver Army Terminal	*Cladophora* species	10	Min.	18.9	37.5	3.3	1.8	480
			Ave.	32.8	54.0	7.8	3.3	1,203
			Max.	63.7	135.0	15.7	6.9	1,620
Astoria	*Cladophora* species	7	Min.	6.6	7.3	0.6	0.5	250
			Ave.	18.9	27.5	8.4	2.3	950
			Max.	35.7	45.9	32.0	7.0	1,550
Fort Stevens	*Zostera marina*	1	Min. Ave. Max.	9.6	1.2	1.6	0.1	2.8
Tillamook Bay	*Zostera marina*	5	Min.	1.8	0.1	0.6	0.2	
			Ave.	2.8	0.2	1.5	0.4	
			Max.	3.4	0.4	2.4	0.5	
Tillamook Bay	*Fucus furcatus*	6	Min.	4.7	0.2	0.2	0.2	
			Ave.	6.3	0.3	0.8	0.4	
			Max.	9.8	0.7	1.3	0.7	
Tillamook Bay	*Enteromorpha compressa*	2	Min.	2.9	0.3	0.3	0.2	
			Ave.	4.9	0.4	0.6	0.4	
			Max.	6.9	0.6	0.9	0.6	

[a] Three samples.

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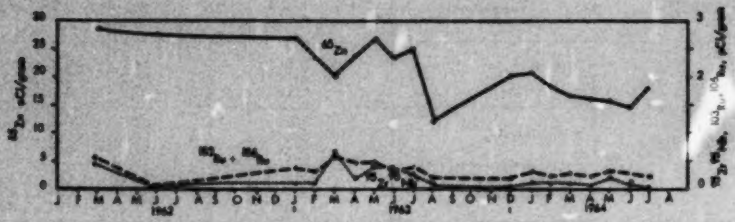

Figure 3. Concentrations of radionuclides in Dungeness crab collected at Astoria

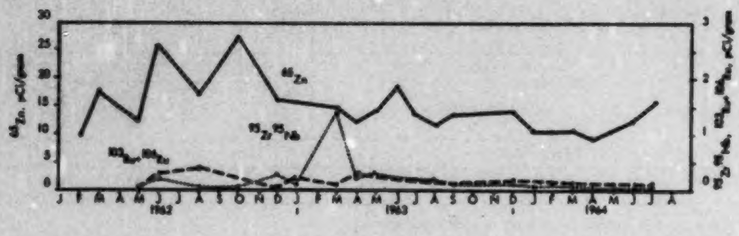

Figure 4. Concentrations of radionuclides in Dungeness crab collected at Tillamook Bay

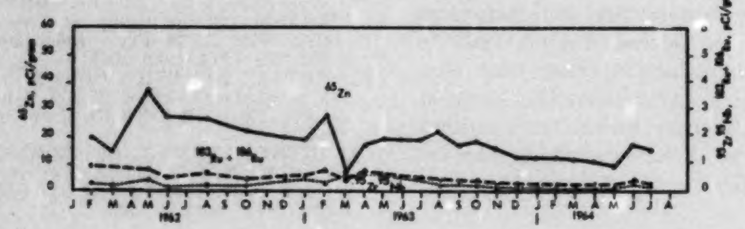

Figure 5. Concentrations of radionuclides in Pacific oysters collected at Tillamook Bay

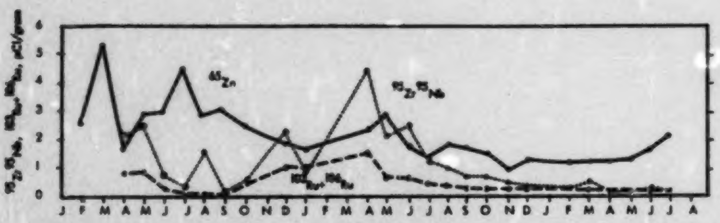

Figure 6. Concentrations of radionuclides in soft shell clams collected at Tillamook Bay

Table 4. Summary of radioactivity in shellfish samples, Columbia River study

(Concentrations in pCi/gram drained weight)

Sample type	Location	Number of Samples	Value	^{40}K	^{65}Zn	^{95}Zr ^{95}Nb	^{103}Ru+ ^{106}Ru
Dungeness crab	Astoria	9	Min.	1.1	12.2	<0.1	0.1
			Ave.	2.1	16.9	0.1	0.2
			Max.	3.0	20.7	0.2	0.3
	Tillamook Bay	10	Min.	1.2	9.4	<0.1	0.1
			Ave.	1.8	12.1	<0.1	0.2
			Max.	2.2	16.1	0.2	0.2
	Alaskan Southern Coastal Area [a]	2	Min.	1.9	<0.2	<0.06	<0.04
			Ave.	2.1	<0.2	<0.06	<0.04
			Max.	2.3	<0.2	<0.06	<0.04
Pacific oysters	Tillamook Bay	[b] 11	Min.	1.3	9.6	<0.1	0.2
			Ave.	2.1	14.6	0.1	0.2
			Max.	3.2	22.1	0.3	0.4
	Yaquina Bay	1		1.5	2.3	<0.1	<0.1
Razor clams (*Siliqua* species)	Seaside	1		3.9	23.8		
Soft shell clams (*Mya arenaria*)	Tillamook Bay	11	Min.	1.8	0.9	0.1	0.1
			Ave.	2.7	1.4	0.4	0.3
			Max.	3.5	2.1	1.0	0.4
Mussels (*Mytilus*)	Cannon Beach	1		2.9	20.0	0.2	0.4
	Nehalem River Jetty	2	Min.	2.8	17.1	0.2	0.5
			Ave.	3.0	18.6	0.2	0.5
			Max.	3.3	20.2	0.2	0.5
	Agate Beach	1		2.0	5.0	<0.1	0.3
Snails (*Thais*)	Nehalem River Jetty	1		3.0	41.5	0.3	0.6

[a] This data has been added for the purpose of comparison.
[b] Three samples.

of 8 x 10^6 pCi/year would be reached only after consuming in excess of 1,000 pounds of these shellfish over the period of one year.

In summary, the radionuclide concentrations measured during the period August 1963 to July 1964 required no action other than continued surveillance to insure that the levels of radioactivity in this environment were neither too high relative to ICRP standards nor increasing too rapidly.

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Recent coverage in *Radiological Health Data:*

Period	Issue
January 1962—July 1963	*August 1964*

Section IV—Other Data

IODINE-131 IN BOVINE THYROIDS, OCTOBER-DECEMBER 1964

Edmond J. Baratta,[1] *Edward R. Williams,*[2] *and George Murray*[3]

To supplement existing environmental radiation surveillance systems, the Division of Radiological Health established a bovine thyroid collection and analysis system on a regular network basis in the fall of 1964. Iodine–131 levels in bovine thyroids were previously investigated in a pilot study (*1, 2*). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The network consists of collection areas (figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear testing sites. In addition, most of the bovine thyroid sampling areas overlap the milksheds serving the metropolitan areas participating in the Pasteurized Milk Network (*3*), and are near a station of the Radiation Surveillance Network (*4*). The thyroid sampling program is designed to permit intercomparison with the data from these two networks.

Thyroid specimens are generally obtained from dairy cows which have been found to be either brucellosis or tuberculosis reactors and are therefore being sent to slaughter. For such animals, a history of their recent forage is readily available, and they are usually killed within 2 to 3 days after leaving the dairy farm. Where such specimens are not available, thyroids from "cutters and canners" cattle are used. These animals are also usually slaughtered near the areas in which they have grazed.

Sample collection and analysis

As they become available at slaughter houses, the thyroids are placed in small glass vials (containing paraformaldehyde), and are shipped to the Northeastern Radiological Health Laboratory. Accompanying each sample is a tag containing information on the age of the cow, area from which she came, and the date of slaughter.

At the Laboratory, the samples are assayed for iodine–131, using a 3– x 3–inch NaI(Tl) well crystal and a multichannel gamma spectrometer. A sample changing unit permits the automatic counting of 100 samples, with the data recorded on a punched-tape read-out. Since counting efficiency varies with sample volume, each sample is weighed and this weight is used to estimate the counting efficieny. The iodine–131 activity is calculated in terms of picocuries per gram of thyroid and corrected for decay back to noon of the slaughtering date. For purposes of quality control, 10 percent of the samples are analyzed a second time and, for those samples containing significant activity (i.e., above 50 pCi/g), decay curves are plotted.

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[1] Mr. Baratta is Director of Analytical Services, Northeastern Radiological Health Laboratory, Division of Radiological Health, Public Health Service, DHEW, 109 Holton Street, Winchester, Massachusetts.

[2] Mr. Williams was Laboratory Coordinator, Division of Radiological Health, Public Health Service, DHEW, Washington, D.C., during this investigation.

[3] Dr. Murray is Staff Officer for Procedures and Requirements, Meat Inspection Division, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C.

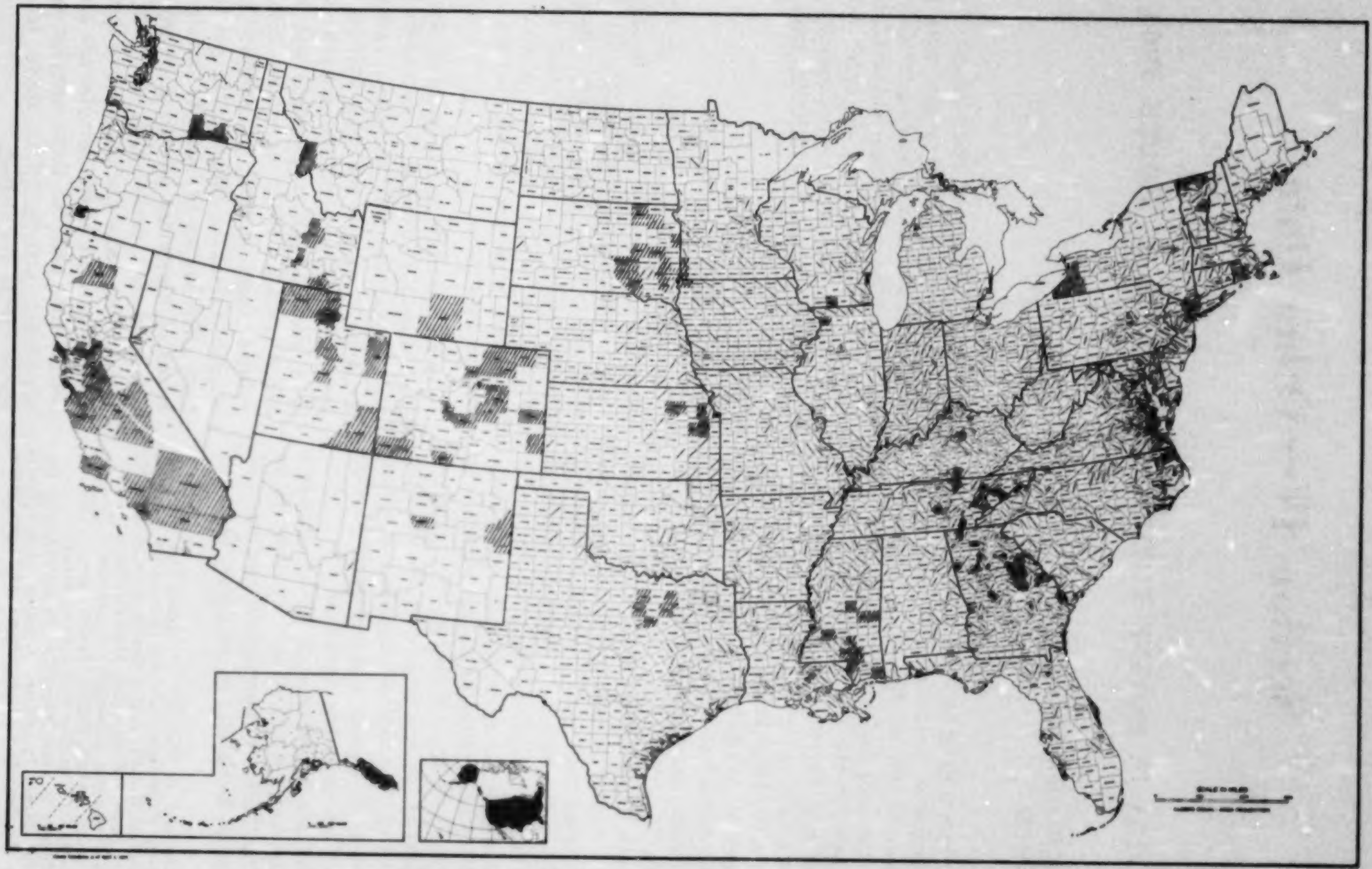

Figure 1. Sample collection areas for the bovine thyroid network

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Table 1. Iodine-131 in bovine thyroids

Origin by State and county	Date of slaughter (1964)	Approximate age or range of ages, years	Iodine-131, pCi/g thyroid	Counting error ᵃ
Calif:				
Los Angeles	11/6	3–4	(b)	(2)
	11/19	6	(b)	(2)
Orange	12/17	5–6	(b)	(2)
Fresno	12/21	4	(b)	(2)
San Joaquin	12/23	4	(b)	(1)
Colo:				
Arapahoe	11/11	(c)	55.80	2.39
	11/18	5	93.36	2.54
Boulder	11/11	4 y 6 mo	121.74	3.30
Chaffee	11/10	4	26.44	2.33
Cheyenne	11/6	4 y 6 mo	74.67	1.68
	11/6	4 y 10 mo	62.41	1.63
	11/6	4 y 6 mo	25.52	1.19
Conejos	11/10	9	28.54	1.62
	11/10	9	23.00	2.15
	11/10	9	23.06	1.43
Denver	12/3	3 y 6 mo	(b)	(1)
Elbert	10/21	2 y 6 mo	1.70	0.91
El Paso	11/25	4–7	(b)	(9)
	12/8	5 y 6 mo	10.31	4.40
Fremont	12/4	5	(b)	(1)
Logan	10/29	6 y 6 mo	2.98	1.96
Morgan	12/11	7	17.69	6.04
Prowers	10/23	6 y 4 mo	(b)	(3)
Unknown	10/28	7	0.96	0.52
Weld	11/12	4	57.77	1.78
	11/13	4	24.93	1.50
Ga:				
Effingham	11/2	6	1.85	0.73
	11/2	6	4.17	0.67
	11/2	7	3.25	0.57
	11/2	6	2.71	1.13
	11/2	7	1.23	0.80
	11/2	6	2.69	1.06
	11/2	6	3.97	0.82
	11/2	6	3.21	0.97
Fulton	12/2	6	(b)	(1)
	12/2	7	3.97	1.42
	12/2	7	6.10	0.92
	12/3	7	8.21	0.77
	12/3	5	5.25	1.18
Greene	11/21	10	1.14	0.74
Hancock	10/23	4	(b)	(1)
Haralson	11/13	9	35.33	1.53
Warren	11/12	6	35.78	1.58
Washington	11/27	6	11.65	1.42
Whitfield	11/13	4	23.24	1.27
	11/27	2 y 6 mo	11.56	1.26
	11/27	1 y 6 mo	24.42	1.55
Wilkes	10/23	6	(b)	(1)
	11/12	7	3.67	0.87
	11/19	8	14.93	1.10
	11/19	9	31.02	1.53
	12/3	2	17.19	1.04
	12/3	4	15.93	1.26
Idaho:				
Butte	11/17	7	13.58	0.83
Oneida	12/7	5	(b)	(1)
	12/7	5	10.37	4.52
	12/7	5	4.75	3.77
	12/7	5	9.50	4.21
Ill:				
Carroll	12/10	4	(b)	(1)
Iowa:				
Lyon	11/18	3	19.38	3.60
Kans:				
Douglas	10/29	4	12.14	1.73
Franklin	11/18	4	55.78	1.62
Osage	11/18	2	4.36	1.67
	12/23	3	2.72	1.11
Pottawatami	(c)	4	1.96	0.56
	(c)	5	2.17	0.32
	(c)	4	0.61	0.43
	(c)	6	(b)	(1)
Riley	12/23	3	(b)	(3)
Wyandotte	12/23	3	(b)	(3)
Ky:				
Wayne	12/2	4	11.31	1.99
	12/2	7	12.40	1.13
	12/2	6	7.99	1.15
	12/2	6	(b)	(1)
Miss:				
Forrest	10/9	6–7	(b)	(2)
	10/23	5–8	(b)	(4)
	10/26	6–10	(b)	(4)
	11/6	3 y 6 mo	28.11	1.54
	11/6	3 y 6 mo	25.06	2.87
	11/10	6	93.40	2.16
	11/10	8	86.96	2.45
	11/13	3 y 9 mo	35.26	1.65
	11/16	8 y 6 mo	31.36	1.61
	11/16	5 y 6 mo	39.25	1.73
	11/16	7	3.55	1.93
	11/16	8	17.96	1.28
	11/17	11	2.61	1.76
	12/1	2	8.40	1.49
	12/1	4	11.19	1.53
	12/7	6 y 6 mo	(b)	(1)
	12/8	7–14	(b)	(2)
	12/8	6	11.41	9.73
	12/9	3–9	(b)	(5)
	12/9	14	14.99	7.77
	12/9	14	15.02	9.44
	12/9	7	7.25	5.62
	12/9	12	12.29	9.81
	12/9	6	20.30	8.09
Jackson	10/6	3 y 6 mo	(b)	(1)
Lamar	10/6	4 y 6 mo	(b)	(1)
	11/10	8	4.74	1.14
	11/10	8	118.84	2.51
	11/10	10	37.73	1.61
	11/20	3	23.39	1.21
Leake	11/21	5 y 6 mo	20.69	1.59
Marion	10/19	6–9	(b)	(2)
	10/26	3	(b)	(1)
	11/10	7 y 6 mo	50.97	1.68
Newton	11/6	2 y 3 mo	30.05	1.64
N.Y:				
Cattaraugus	11/3	13	145.64	3.22
	11/3	11	0.44	0.72
	11/3	9	280.14	3.54
	11/3	10	39.06	2.05
	11/14	13	77.30	1.72
	11/14	13	82.38	2.75
	12/17	12–12 y 8 mo	(b)	(5)
	12/24	12–12 y 6 mo	(b)	(6)
	12/31	12	2.50	2.11
	12/31	12–12 y 8 mo	(b)	(5)
Chautauqua	10/28	9–10	(b)	(2)
	10/28	12	8.54	1.11
	10/28	14	82.45	1.60
	11/5	9	(b)	(1)
	11/5	10	14.45	1.11
	11/5	11	6.92	0.78
Erie	10/23	9	2.45	0.48
	10/23	10–13	(b)	(3)
	10/29	10	11.31	1.32
	10/29	10	31.22	1.05
	10/29	8	173.88	1.99
	11/5	12	34.02	1.72
	11/12	9	13.25	1.35
	11/12	11	49.07	1.13
	11/12	8	16.43	1.15
	11/12	10	28.22	1.49
	11/19	4	(b)	(1)
	11/19	6	10.33	1.02
	11/19	8 y 9 mo	8.32	1.06
	11/27	10	2.98	0.87
	11/27	3 y 6 mo	58.78	0.67
	11/27	5 y 6 mo	7.25	0.99
	11/27	8	(b)	(1)
	11/27	7	7.45	0.87
	11/27	5 y 4 mo	5.23	0.74
	12/3	8 y 6 mo	5.05	0.92
	12/3	9 y 9 mo	5.41	0.96
	12/3	7	6.21	0.36
	12/3	5	3.91	1.54
	12/3	8	1.16	0.77
	12/3	6	(b)	(1)
	12/3	9	3.41	3.41
	12/10	7	4.19	3.33
	12/10	8–12	(b)	(3)
Minn:				
Rock	11/3	8	34.51	0.97
Mont:				
Ravalli	11/18	6	12.97	1.15
S. Dak:				
Day	12/2	2	9.78	1.32
	12/2	2	10.21	2.25
	12/2	2	1.81	1.73
	12/2	2	1.78	1.15
	12/2	2 y 6 mo	6.42	2.03
	12/2	2	9.10	1.24
	12/2	1 y 6 mo	6.79	2.04
Deuel	11/18	9	(b)	(1)
Tenn:				
Blount	12/2	6	2.26	1.46
Bradley	11/27	5	16.45	1.26
	11/27	7	5.43	0.69
	11/27	8	10.92	0.79

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Table 1. Iodine-131 in bovine thyroids—Continued

Origin by State and county	Date of slaughter (1964)	Approximate age or range of ages, years	Iodine-131, pCi/g thyroid	Counting error [a]
Tenn: (Continued)				
Bradley	12/2	6	15.71	1.88
	12/2	6	29.60	1.27
	12/2	7	22.80	1.40
Knox	12/2	6	3.23	0.89
Union	12/2	7	29.10	1.56
Tex:				
Dallas	12/4	9	(b)	(1)
Johnson	11/12	4	(b)	(1)
	11/12	5	4.43	1.30
Parker	10/21	4–6	(b)	(5)
Utah:				
Box Elder	11/7	5	(b)	(1)
	11/7	5	4.28	0.79
Cache	11/12	5	27.89	1.39
	11/12	5	15.35	1.34
	11/12	5	(b)	(1)
	11/12	5	19.00	0.94
	11/12	5	12.18	0.97
	11/12	5	35.32	1.71
	11/12	5	17.21	1.26
	11/12	5	27.52	1.53
	11/13	5	(b)	(2)
	11/13	5	1.09	0.85
	11/13	5	1.09	0.98
	11/14	4	38.33	1.71
	11/14	4	40.53	1.57
	11/14	4	46.41	1.53
	11/14	4	26.61	1.07
	11/14	4	31.47	0.96
	11/14	4	48.34	1.33
	12/3	5	(b)	(2)
	12/9	5	(b)	(1)
Vt:				
Orleans	12/17	6	(b)	(1)
Wash:				
Benton	11/19	5 y 5 mo	(b)	(2)
	11/19	4	4.35	1.33
	11/19	5	9.76	1.68
	11/19	5	17.51	2.03
Walla Walla	12/14	4	2.00	1.90
	12/14	5	2.55	3.36
	12/14	3	5.01	1.95
	12/14	5	4.67	3.23
	12/31	5	7.73	2.73
	12/31	4–7	(b)	(8)
	12/31	5	3.99	3.61
	12/31	5	4.51	3.46
Wis:				
Green	11/14	6	49.52	2.04
	11/16	3	1.80	0.98
	11/16	3	31.89	1.81
	11/16	3	22.72	1.59
	11/16	3	21.35	1.80
	11/16	3	30.23	1.85
	11/16	6	13.84	1.10
	11/16	3	50.10	1.95
	11/16	3	7.87	1.31
	11/16	3	3.15	1.13
	11/16	3	3.04	1.26
	11/16	5	18.09	1.29
	11/16	5	10.62	1.40
	11/16	3	25.21	1.37
	11/16	6	6.16	1.92
	11/16	6	14.09	1.27
	11/16	3	13.88	1.18
Ozaukee	11/12	7	63.48	1.93
	11/12	7	77.25	2.29
Wyo:				
Carbon	12/8 [d]	4	7.77	0.73

[a] Two standard deviations. Number of samples shown in parentheses.
[b] Observed value equal to or less than 2σ counting error.
[c] Information not available, iodine-131 reported as of date counted (11/4/64).
[d] Date counted.

Results and conclusions

Data reported in this paper include those values obtained from October through December 1964, a period during which iodine–131 contamination was observed in many areas of the United States, presumably as a result of the atmospheric detonation of a nuclear device on the Chinese mainland on October 16, 1964. Iodine–131 levels in thyroids collected during this period are recorded in table 1. For the sake of brevity, complete data are given for only those samples having iodine–131 concentrations above the minimum detectable level (above 2σ level). For samples containing less than the minimum detectable level, only the number of specimens is given. In addition, the weights of the indivdual samples have also been omitted. In general they ranged from 10 to 15 grams each.

Figures 2–5 show concentrations of iodine–131 in thyroids during the October–December interval for four selected locations in Colorado, Georgia, New York, and Mississippi. These graphs also show the daily levels of gross beta radioactivity in air (*5*), and the weekly concentrations of iodine–131 in fluid milk samples

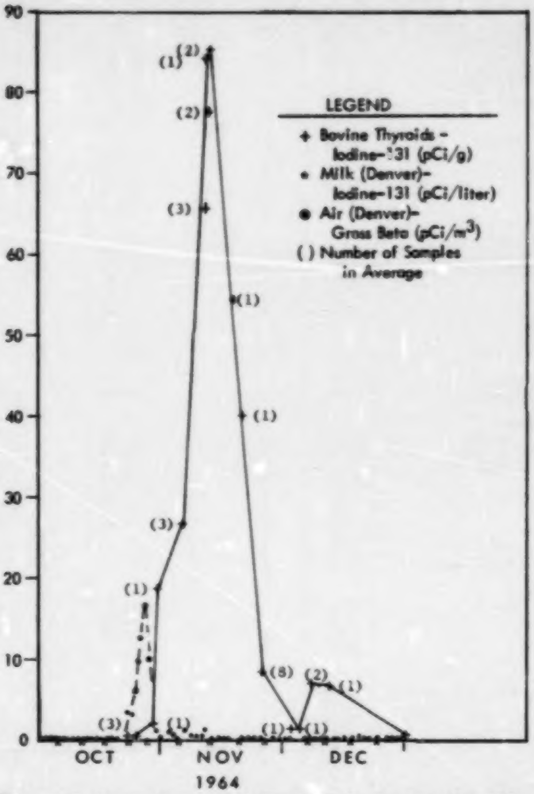

Figure 2. Appearance of iodine–131 in bovine thyroids, fall 1964, Colorado

as reported to the Radiation Surveillance Center, Division of Radiological Health (*5*).

The Colorado, Georgia, and New York air and milk samples were collected in the same general area where the cows foraged before being sent to slaughter, but the Mississippi air and milk samples were collected in Jackson (located in the central portion of the State), while the thyroids were obtained from cows which had been on farms in the vicinity of Hattiesburg (located near the southern part of the State, about 95 miles from Jackson).

In the case of the pasteurized milk data, Atlanta failed to show any increase to detectable levels and in the other three cites (Buffalo, Denver, and Jackson) the increases were only minimal (*i.e.*, up to a maximum of 20 picocuries per liter). Had the sampling frequency of the milk network been greater, it is possible that the intrusion would have been more clearly indicated. Considering that the intrusion was essentially a single contaminating event, it is interesting to note that the effective half life of the iodine–131 in the thyroids in all four locations ranged from about 3 to 6 days. This closely parallels previously reported data for the half-time of this nuclide in the milk after deposition on pasture under similar conditions (*6*).

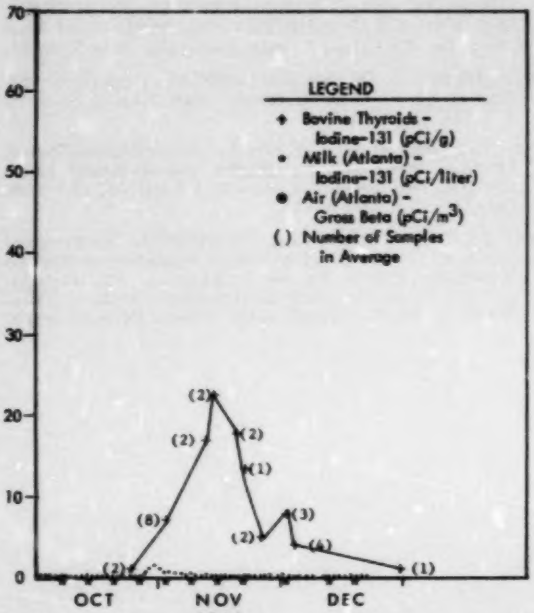

Figure 3. Appearance of iodine–131 in bovine thyroids, fall 1964, Georgia

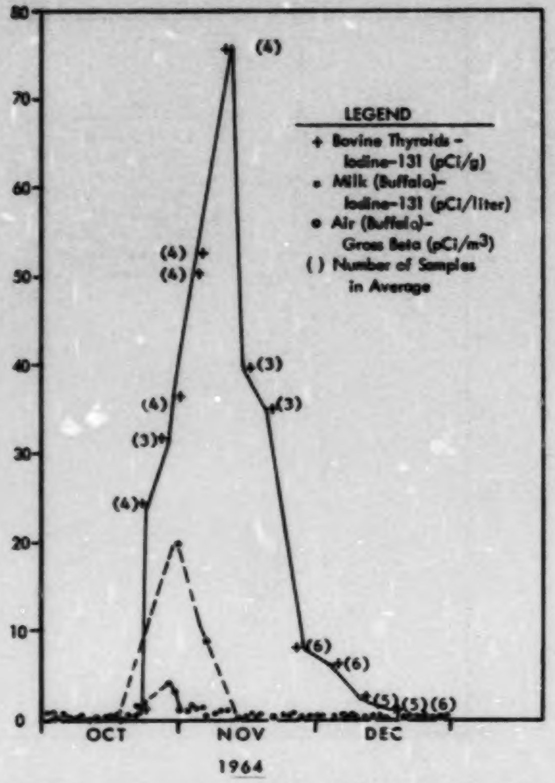

Figure 4. Appearance of iodine–131 in bovine thyroids, fall 1964, New York State

On the basis of these data, it can be concluded that the collection and analysis of bovine thyroids is an extremely sensitive method for the detection of environmental iodine–131 intrusions. Although this approach is not as quick in its response as the determination of radioactivity levels in air, it is specific for this radionuclide and, in that sense, it is an excellent supplementary environmental assessment tool.

Although the data are limited, several facts are evident. In all four of the plotted locations, the intrusion was clearly delineated by the thyroid data. At every location there was also some increase in air radioactivity levels prior to the detection of iodine–131 in the thyroids. For Denver, the increase was very pronounced; for Atlanta, it was barely detectable. In this regard, it is pointed out that the air data shown are those obtained through counting the filter-trapped particulates in the laboratory. The field estimates of gross beta activity in these same samples showed considerably more scatter. Regardless of whether the laboratory or

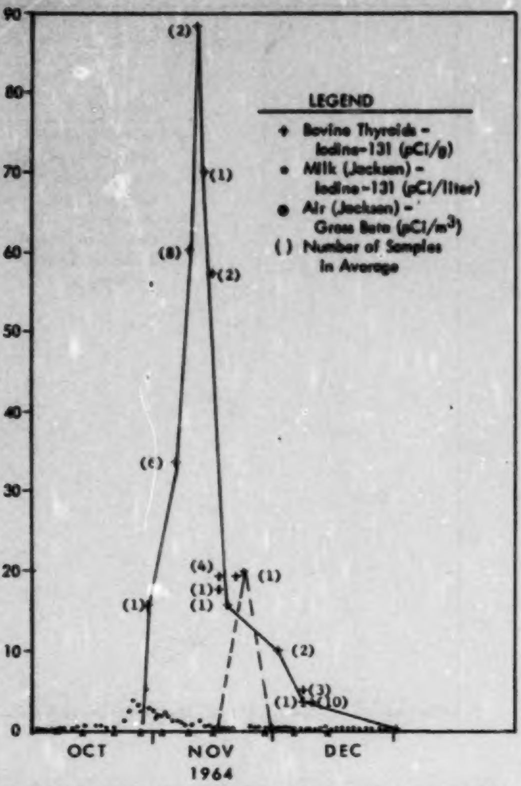

Figure 5. Appearance of iodine-131 in bovine thyroids, fall 1964, Mississippi

field air data were used, however, with the possible exception of Denver, the intrusion was much less clearly delineated by the air data than by the thyroid data.

In the case of the pasteurized milk data, Atlanta failed to show any increase to detectable levels and in the other three cities (Buffalo, Denver, and Jackson) the increases were only minimal (*i.e.*, up to a maximum of 20 picocuries per liter). Had the sampling frequency of the milk network been greater, it is possible that the intrusion would have been more clearly indicated. Considering that the intrusion was essentially a single contaminating event, it is interesting to note that the effective half life of the iodine-131 in the thyroids in all four locations ranged from about 3 to 6 days. This closely parallels previously reported data for the half-time of this nuclide in the milk after deposition on pasture under similar conditions (*6*).

On the basis of these data, it can be concluded that the collection and analysis of bovine thyroids is an extremely sensitive method for the detection of environmental iodine-131 intrusions. Although this approach is not as quick in its response as the determination of radioactivity levels in air, it is specific for this radionuclide and, in that sense, it is an excellent supplementary environmental assessment tool.

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STRONTIUM-90 IN HUMAN VERTEBRAE, 1964 RESULTS[1]

Joseph Rivera[2]

Since 1961, the Health and Safety Laboratory (HASL) has been obtaining specimens of human vertebrae for strontium–90 analyses in New York City, Chicago, and San Francisco. The specimens are from accident victims or from individuals whose metabolism and diet can be assumed to have been normal prior to sudden death. The results of analyses of samples obtained in 1964 are summarized in table 1; details of results are shown in tables 2–4.

Where there were a sufficient number of samples at each age to make valid comparisons, the highest strontium–90 concentrations were found in bones from New York City, the lowest concentrations were found in bones obtained in San Francisco, and intermediate concentrations were found in bones obtained in Chicago. These results are in agreement with the findings of the HASL Tri-City diet strontium–90 studies (*1*).

Table 1. Average pCi strontium-90/g calcium in vertebrae

Age (years)	New York City	Chicago	San Francisco
0–4	[a] 5.90 (23)	1.95 (1)	2.65 (42)
5–19	3.07 (33)	3.26 (5)	1.66 (27)
20 and over	2.09 ([illegible])	1.45 (43)	1.23 (11)

[a] Parentheses indicate number of samples

Since the start of the HASL bone sampling program in 1961, 212 specimens of vertebrae from New York City residents, up to 20 years of age at death, have been analyzed for strontium–90. The results of these analyses were

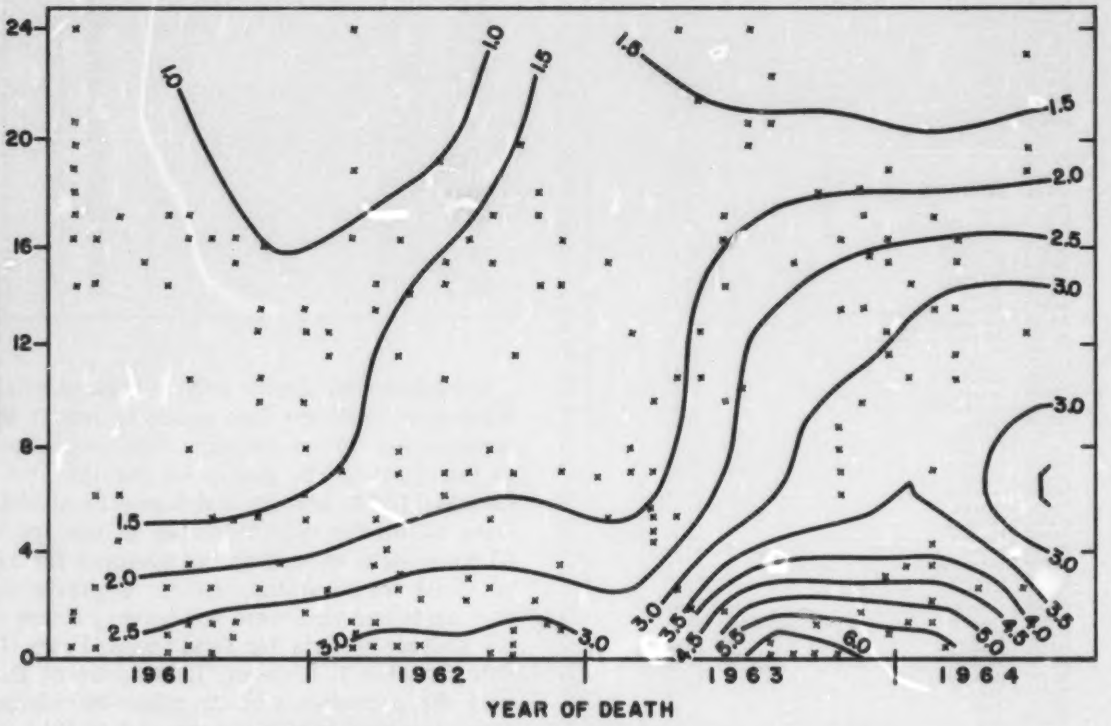

Figure 1. Isopleths of strontium–90 (pCi/g Ca) in New York City vertebrae

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[1] Summarized from *Fallout Program Quarterly Summary Report*, HASL—161:296–306. Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151 (July 1, 1965). Price $4.00.

[2] Mr. Rivera is a physicist on the staff of Environmental Studies Division, U.S. Atomic Energy Commission's Health and Safety Laboratory, 376 Hudson Street, New York, New York 10014.

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used to construct figure 1, using a standard numerical approximation program for a digital computer.

From figure 1, the variation of strontium-90/calcium ratios with age (*i.e.*, highest levels for young children and lower levels for adults) that has been noted previously (*2*), is quite apparent. In addition, the general increase with time in strontium-90 levels for indviduals of all ages, associated with increased diet strontium-90/calcium ratios starting in early 1963 (*3*), is also readily seen.

Table 2. Strontium-90 in human vertebrae New York City, 1964

HASL No.	Date of death	Age	pCi/g Ca
B3036	January	3 mo.	7.40
B3054	January	1 mo.	7.40
B3057	February	3 mo.	7.40
B3102	April	11 mo.	9.94
B3108	April	7 mo.	9.94
B3157	May	4 mo.	7.11
B3164	May	5 mo.	7.11
B3169	May	9 ds.	7.11
B3151	May	1 wk.	6.19
B3155	May	11 mo.	6.19
B3043	January	18 mo.	5.10
B3167	May	18 mo.	5.38
B3140	June	18 mo.	5.10
B3313	September	18 mo.	4.19
B3055	February	30 mo.	4.40
B3096	March	24 mo.	4.40
B3142	June	24 mo.	8.30
B3158	June	30 mo.	6.76
B3090	April	3 yr.	1.90
B3315	August	3 yr.	5.48
B3298	October	3 yr.	2.26
B3162	May	4 yr.	5.40
B3139	June	4 yr.	3.32
B3147	June	5 yr.	2.69
B3041	February	6 yr.	2.55
B3061	February	7 yr.	2.88
B3161	May	7 yr.	4.79
B3051	February	8 yr.	4.02
B3143	June	8 yr.	3.15
B3047	February	9 yr.	4.92
B3049	February	10 yr.	3.19
B3097	March	11 yr.	2.55
B3154	May	12 yr.	4.48
B3321	July	12 yr.	4.04
B3092	April	13 yr.	2.34
B3225	July	13 yr.	4.07
B3100	April	14 yr.	3.06
B3326	October	14 yr.	2.73
B3048	February	15 yr.	3.06
B3095	March	15 yr.	2.72
B3148	June	15 yr.	3.61
B3312	July	15 yr.	3.82
B3163	May	16 yr.	2.46
B3098	March	17 yr.	2.79
B3108	April	17 yr.	3.00
B3227	July	17 yr.	3.15
B3371	November	17 yr.	2.94
B3058	February	18 yr.	2.81
B3053	February	18 yr.	2.56
B3060	February	18 yr.	3.83
B3101	April	18 yr.	2.72
B3319	July	18 yr.	2.10
B3367	December	18 yr.	2.30
B3104	March	19 yr.	1.77
B3105	March	19 yr.	1.65
B3150	June	19 yr.	2.77
B3038	January	20 yr.	2.05
B3099	March	20 yr.	1.61
B3373	November	20 yr.	2.65
B3106	April	21 yr.	1.47
B3322	October	21 yr.	2.11
B3330	October	22 yr.	1.67
B3372	October	26 yr.	1.35
B3032	January	33 yr.	1.62
B3307	October	36 yr.	2.08
B3304	October	37 yr.	2.70
B3301	October	37 yr.	1.54
B3327	October	38 yr.	1.22
B3141	June	42 yr.	1.77
B3320	September	41 yr.	1.89
B3305	October	45 yr.	2.07
B3303	October	48 yr.	1.31
B3302	October	48 yr.	1.40
B3310	October	49 yr.	1.73
B3165	May	50 yr.	2.94
B3146	June	60 yr.	2.10
B3159	June	67 yr.	1.97
B3306	September	65 yr.	2.49
B3160	May	70 yr.	3.92
B3149	June	75 yr.	2.39
B3228	July	88 yr.	2.38

Table 3. Strontium-90 in human vertebrae, Chicago, 1964

HASL No.	Date of death	Age, yrs.	pCi/g Ca
B3295	December	3.5	1.95
B3283	July	5	5.40
B3362	November	5	3.51
B3290	November	15	2.30
B3123	March	17	1.69
B3293	November	17	3.40
B3086	March	22	1.50
B3284	May	23	1.19
B3219	August	25	1.98
B3274	August	28	2.65
B3082	March	29	1.48
B3083	March	30	1.14
B3137	June	31	1.51
B3272	August	35	2.38
B3360	September	35	2.27
B3217	October	35	1.78
B3084	March	37	1.02
B3081	April	39	0.87
B3224	August	39	2.78
B3218	August	40	1.62
B3270	June	42	1.05
B3135	July	42	1.35
B3085	March	43	0.53
B3128	March	43	0.81
B3220	April	43	1.99
B3279	June	43	0.99
B3112	April	44	1.03
B3131	June	44	1.27
B3223	August	44	1.46
B3110	March	45	1.37
B3111	March	45	1.06
B3138	June	45	0.97
B3271	July	46	0.54
B3363	July	46	1.66
B3134	July	47	1.81
B3133	May	49	1.64
B3136	June	49	1.24
B3119	March	50	1.89
B3028	March	56	0.87
B3266	October	57	1.51
B3122	March	63	1.32
B3025	March	64	1.66
B3109	March	69	1.43
B3024	March	76	0.94
B3114	March	78	1.76
B3026	March	82	1.26
B3126	March	83	1.43
B3089	March	88	1.42
B3030	March	97	1.75

Contours were drawn only in regions where there were sufficient data points to justify the construction. Thus contours were not drawn at the edges of the graph, *i.e.* for the first 6 months of 1961 and the last 6 months of 1964. Data points for individuals up to the age of 25 were included so that the contours for age 20 could be accurately drawn. Contours for ages up to one year were not drawn because of the absence of data for fetal bones. From the data in table 1, however, it is apparent that very sharp gradients in strontium-90/calcium ratios occurred in this age interval in 1964.

Table 4. Strontium-90 in human vertebrae, San Francisco, 1964

HASL No.	Date of death	Age	pCi/g Ca
B3286	May	1 da.	1.34
B3262	May	1 da.	2.71
B3291	May	1 da.	2.71
B3251	May	2 da.	2.32
B3234	October	2 da.	2.71
B3069	March	4 da.	2.52
B3017	March	8 da.	1.96
B3015	January	10 da.	1.95
B3240	October	2 wk.	3.14
B3334	January	3 wk.	1.19
B3353	October	3 wk.	1.10
B3239	August	1 mo.	2.71
B3238	September	1 mo.	2.71
B3230	September	2 mo.	2.71
B3241	September	2 mo.	3.14
B3281	May	2 mo. 15 da.	2.71
B3165	March	3 mo.	2.52
B3066	March	3 mo.	2.71
B3064	February	4 mo.	2.52
B3246	May	4 mo.	2.32
B3254	May	4 mo.	4.44
B3244	June	4 mo.	2.71
B3337	November	4 mo.	3.38
B3259	July	6 mo.	1.34
B3018	March	7 mo.	2.71
B3255	May	7 mo.	4.44
B3014	January	11 mo.	1.96
B3336	November	11 mo.	3.38
B3013	February	12 mo.	2.90
B3249	April	12 mo.	6.49
B3256	June	12 mo.	2.44
B3179	July	12 mo.	3.05
B3264	October	12 mo.	2.44
B3201	March	14 mo.	3.05
B3067	February	18 mo.	2.91
B3177	February	18 mo.	2.12
B3229	October	24 mo.	1.98
B3068	February	24 mo.	2.90
B3235	February	24 mo.	2.90
B3087	April	36 mo.	1.95
B3077	January	3 yr.	2.09
B3232	September	3 yr.	1.55
B3070	February	5 yr.	2.86
B3071	March	5 yr.	1.41
B3342	December	5 yr.	2.51
B3260	July	6 yr.	1.61
B3012	January	6 yr. 6 mo.	1.29
B3205	January	7 yr.	2.24
B3211	May	7 yr.	1.37
B3213	August	7 yr.	1.71
B3251	May	7 yr.	2.90
B3079	February	8 yr.	1.10
B3198	June	8 yr.	1.72
B3184	June	10 yr.	1.63
B3009	February	10 yr.	0.98
B3237	September	11 yr.	1.39
B3183	August	13 yr.	2.33
B3346	December	13 yr.	2.00
B3020	March	14 yr.	0.88
B3261	May	14 yr.	1.43
B3248	May	14 yr.	1.08
B3181	April	15 yr.	1.57
B3011	January	16 yr.	1.48
B3231	October	16 yr.	1.31
B3192	March	17 yr.	0.40
B3196	June	17 yr.	1.46
B3006	January	18 yr.	0.98
B3190	August	18 yr.	3.87
B3240	October	18 yr.	1.19
B3002	January	20 yr.	1.22
B3180	February	20 yr.	1.32
B3172	June	20 yr.	1.40
B3008	January	22 yr.	1.62
B3005	January	23 yr.	1.18
B3001	January	45 yr.	1.06
B3007	February	45 yr.	1.22
B3000	January	47 yr.	0.81
B3010	February	51 yr.	1.08
B3003	July	51 yr.	1.46
B3004	January	73 yr.	1.17

In HASL–146 it was shown that the increases in the strontium–90 content of adult vertebrae from 1962 to 1963 could be predicted from the observed diet levels in 1963, assuming a bone-diet observed ratio of 0.25 and an annual bone turnover rate of 9 percent per year. The equation describing the relationship is:

$$x_n = x_{n-1} - f x_{n-1} + f k z_{n-1}$$

where x_n is the average strontium–90/calcium ratio observed in year 'n', x_{n-1} is the average ratio observed during the previous year, f is the annual bone turnover rate, k is the bone-diet observed ratio, and z_{n-1} is the average $^{90}Sr/Ca$ ratio of the diet during the year n–1.

Using estimates of z_{n-1} from the Tri-City Diet studies, and 1964 estimates of x_{n-1} from HASL–146, gives:

New York City

$$x_n = 1.55 - (.09)(1.55) + (.09)(.25)(32)$$
$$= 2.13 \qquad \text{(observed } x = 2.02\text{)}$$

Chicago

$$x_n = 1.11 - (.09)(1.11) + (.09)(.25)(20)$$
$$= 1.46 \qquad \text{(observed } x = 1.46\text{)}$$

San Francisco

$$x_n = 0.94 - (.09)(0.94) + (.09)(.25)(14)$$
$$= 1.18 \qquad \text{(observed } x = 1.23\text{)}$$

The agreement between calculated and observed strontium–90/calcium ratios in adult vertebrae indicate the validity of the bone sampling as well as the accuracy of the Tri-City diet strontium–90 estimates.

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(*3*) U.S. ATOMIC ENERGY COMMISSION. Daily intake of strontium–90 in New York City, Chicago and San Francisco. Atomic Energy Commission Report No. HASL–161:215, fig. 8. (July 1, 1965).

PROJECTED VALUES OF CESIUM-137 BODY BURDENS IN ANAKTUVUK PASS ESKIMOS FOR THE SUMMER OF 1965, BASED ON FINDINGS IN CARIBOU MUSCLE[1]

James R. Coleman[2]

The discovery of relatively high levels of fallout radionuclides in arctic ecosystems has stimulated interest both nationally and internationally (*1, 2*). The first studies related to radionuclides in Alaskan ecosystems began in 1959 in connection with Project Chariot (*3, 4*). After the finding of high levels of cesium–137 in lichens and caribou, the studies were extended in 1962 to include whole body counting of Eskimos (*5*). This report describes a method for predicting values of body burdens that might be expected in Anaktuvuk Pass Eskimos and to present the estimated values for the summer of 1965. The data used are the cesium–137 whole body counting data reported for a control group of 21 adult Anaktuvuk Pass inhabitants (*5, 8, 9, 11*), and the concentration of cesium–137 in caribou flesh obtained as part of the cooperative program between the State of Alaska and the Public Health Service (*6, 7*).

Among the facts that have emerged from the Alaskan studies are:

1. The people of the interior village of Anaktuvuk Pass have consistently shown the highest average body burdens of cesium–137 (*3, 9*) among Alaskan peoples.
2. There is a definite seasonal variation in body burdens in individuals from this village. The highest body burdens observed have occurred during July and the lowest, during the winter months (*9*).
3. The average body burdens of the inhabitants of Anaktuvuk Pass appear to be directly related to the amounts of cesium–137 in caribou (*9*).

Because of the growing interest in fallout radionuclides as related to Anaktuvuk Pass villagers and the importance of anticipating future body burdens, this attempt has been made to devise methods by which one might, with reasonable accuracy, project current data forward in time in order to arrive at estimates of the cesium–137 body burdens that might be experienced by the inhabitants of Anaktuvuk Pass at some future time. Although general long-term predictions have been made by others (*10*), this report is limited to short-term projections.

The method proposed evaluates the available data in terms of simplified considerations and is not intended to define basic biological parameters or ecological situations. The lack of definitive and complete biological and ecological information can be overcome only by additional study.

Model and assumption

The predictive equation represents a model which must include basic assumptions related to local ecology and native habits. These assumptions are by necessity simplifications, made in order to supplement the available data. Four basic simplifying assumptions have been made in this analysis, and are as follows:

1. The accumulation of cesium–137 in both caribou and man can be characterized by a single-compartment exponential model.
2. The cesium–137 intake for caribou might, within reason, be characterized by a square wave. That is, the caribou intake may be considered to result from two rather distinct seasonal diet patterns.
3. During periods of low cesium–137 intake by the caribou, a base level of 0.7 nCi/kg would be reached in caribou flesh.
4. The dietary intake of cesium–137 of the Anaktuvuk villagers could be expressed as a square wave, related to two major periods of caribou slaughtering.

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[1] Manuscript for this article, including the values shown in the text, was submitted to the Editorial Committee, Division of Radiological Health, July 6, 1965. Since this date, tentative data on the average cesium–137 body burdens of the Anatuvuk Pass control group, secured under the auspices of the Atomic Energy Commission on July 23–24, 1965 indicate good agreement of the projected values, with the actual values being somewhat lower.

[2] Mr. Coleman is Chief, Data Collation and Analysis Section, Radiation Surveillance Center, Division of Radiological Health, Public Health Service, Washington, D.C.

In general, these assumptions, although gross simplifications of complex factors, are considered to be reasonable as an initial approach. Cesium-137 retention (assumption 1) may be more accurately described by a multicomponent model (*12–14*). However, such a refinement would appear to be of little overall importance considering other inaccuracies inherent in the method used.

The second assumption, although more of a simplification than the first, may be rationalized primarily on the basis of changing seasons and the availability of forage. Inherent in this assumption is the selection of specific periods for the caribou diet changes related to the square wave function. Although seasons do not change abruptly, transitional periods, as related to feeding habits, may be relatively short. For this analysis the dates selected need not define actual dates of significant diet changes, but need only have a general relationship to the changing situation. Fortunately, this does not appear to be critical and must be predicted on the greatest extent on approximating the observed caribou data. Thus, the periods or dates of caribou diet changes selected represent a balanced average related to seasonal changes, but are inherently a function of the model and data themselves.

The third assumption, made solely to supplement existing data, was based on the consideration of two data points, one in October 1962 and the other in August 1964. It is difficult to say how close this assumption relates to the actual situation; however, since the levels in caribou flesh during these periods appear to be roughly an order of magnitude less than the levels during the high periods, an error in this assumption would not be greatly limiting. This assumption does not imply that the actual level of cesium-137 in caribou flesh is constant over the period of concern, but only that for the purpose of relating these levels to the intake by the Eskimos, they may be represented by a single value.

The fourth assumption is directly related to the caribou migration and thus the caribou killing and storage habits of the Eskimos. The migrations of the caribou in the central Brooks Range are very complex and are not well understood. However, from about early June until early August caribou are usually absent from the main valley at Anaktuvuk Pass (*15*). During the period of absence of caribou, the villagers utilize a store of previously killed caribou kept in underground caches. This storage of meat botained from the spring kill (period of high concentration of cesium-137 in caribou) supports, in part, the concept of a square-wave intake for the villagers. As with assumption two, there is inherent in this assumption a selection of exact periods or dates of diet change. Again, this selection is predicated primarily on fitting the observed data, and thus the dates selected can be considered only general periods, weighted by the data, but supported by a general knowledge of caribou hunting and storage habits.

Once the above assumptions have been made, one may proceed with an attempt to fit the available data to a projection model. The method used involved two steps: First, on the basis of assumption number one, an equation of the form shown below (equation 1) was fitted to the caribou data using the square wave intake pattern, and the result projected in time through the summer of 1965:

$$(1)\quad B_i = A_i\left[1-\exp\left(-\frac{0.693}{T_e}t_i\right)\right] + B_{i-1}\exp\left(-\frac{0.693}{T_e}t_i\right)$$

Where: T_e = Effective half life of cesium-137 in caribou muscle (days)

t_i = Time interval of concern (consistent units with T_e)

B_i = Level of activity in caribou muscle at end of time interval t_i (nCi/kg)

B_{i-1} = Level of activity in caribou muscle at beginning of time interval t_i (nCi/kg)

A_i = A factor relating to the caribou intake of cesium-137 over the period t_i (selected in a square wave pattern so that the available caribou muscle data might be reasonably approximated).

Second, using the estimated levels of cesium-137 in caribou muscle during the periods intermediate to actual sampling and related to the selected periods of human diet changes, the square wave intake pattern for the Eskimo was obtained. A similar equation (equation 2) was then fitted to the observed average body burdens. Once reasonable relationships were set up, the average body burdens for the inhabitants were projected through the summer of 1965.

$$(2)\quad \beta_i = aI_i\left[1-\exp\left(-\frac{0.693}{\tau_e}t_i\right)\right] + \beta_{i-1}\exp\left(-\frac{0.693}{\tau_e}t_i\right)$$

Where: τ_e = Effective half-life of cesium-137 in population of concern (days)

t_i = Time interval of concern (consistent units with τ_e)

β_i = Body burden at end of time interval t_i (μCi)

β_{i-1} = Body burden at beginning of time interval t_i (μCi)

I_i = Intake concentration in caribou (nCi/kg)

a = A constant relating to the Eskimo's intake of caribou (μCi per nCi/kg).

Results

The detailed curves arrived at for the concentration in caribou muscle and average body burden of the villagers are shown in figures 1 and 2, respectively. From figure 1, it may be seen that there has been an apparent decrease in the cesium-137 concentration in caribou muscle in March of this year as compared to the estimated value for March of 1964 (period selected for spring eskimo diet change). This, as shown in figure 2, would lead to slightly decreased body burdens in the summer of 1965 as related to the summer of 1964.

Using the curve presented in figure 2, the following comparison may be made between the estimated body burdens for the summer of 1964 and those projected for the summer of 1965:

	1964	1965
July 1	1.2μCi	0.88μCi
August 1	1.35μCi	0.94μCi

The average body burdens over specified time periods is also of interest for comparison to existing guidance. Since a reasonably continuous function has been fitted to the data, average

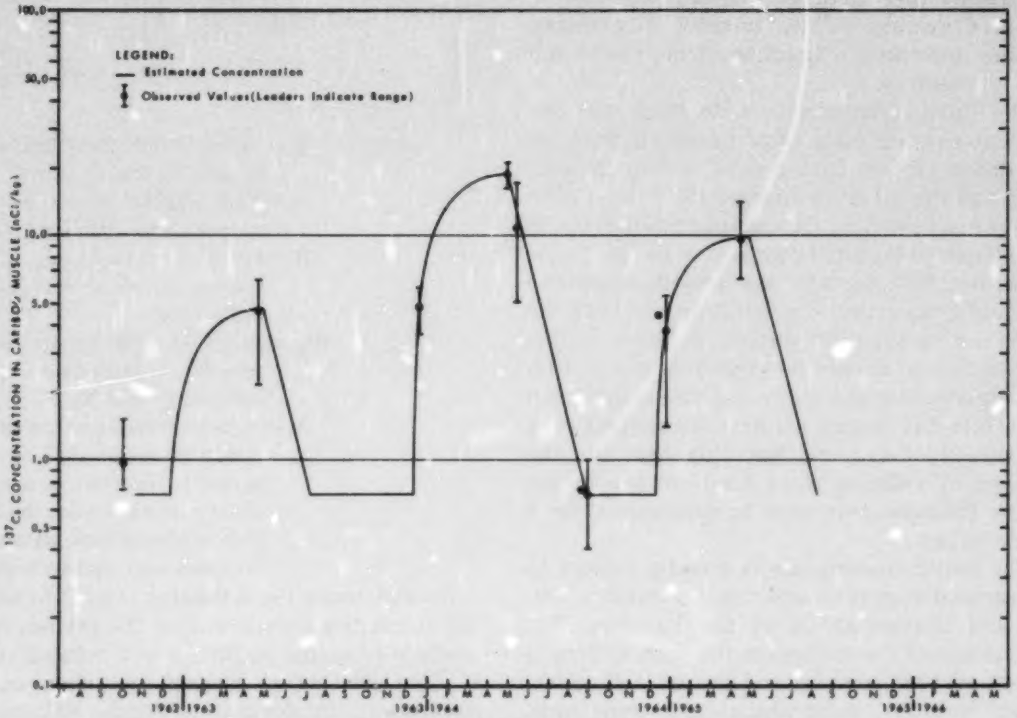

Figure 1. Projected and observed cesium-137 concentrations in caribou muscle for Anaktuvuk Pass area

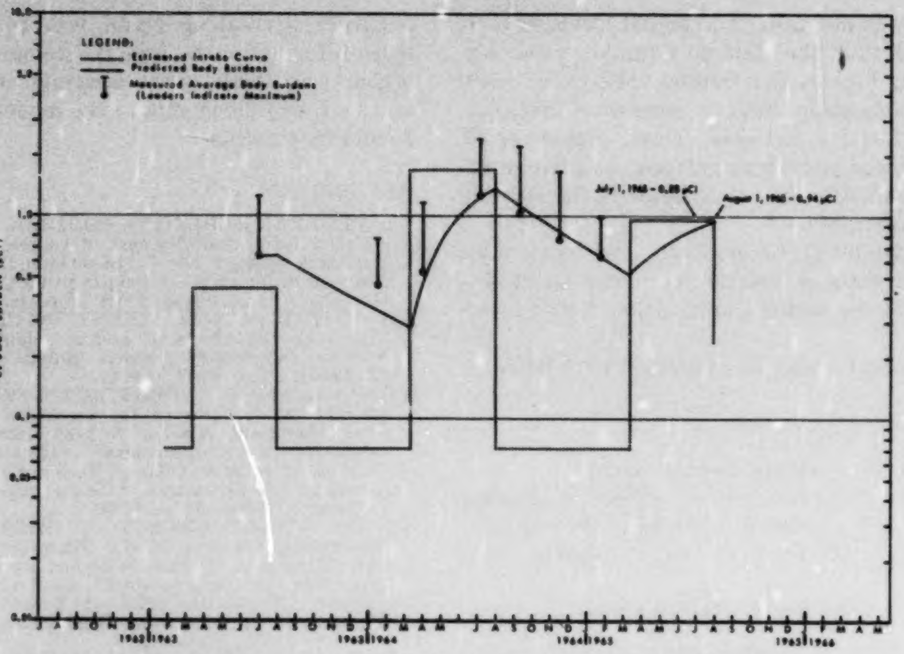

Figure 2. Body burden and estimated intake curves for Anaktuvuk Pass villagers

body burdens over various time periods may be mathematically calculated from the curve shown in figure 2. The following annual averages have been obtained:

	1964	1965
Annual average body burden for adult villagers	0.82μCi	0.70μCi

Discussion

From figure 1, it may be observed that the caribou muscle data may be reasonably described by the method used and the assumption made. In order to apply the equation presented, an effective half-life for cesium–137 in caribou muscle under range conditions had to be selected. By consideration of the data obtained during the year 1964, the effective half-life was approximated to be 26 days. Although this value should not be considered as representing true biological half-life, it is in reasonable agreement with values observed in other animals (*16–18*). The dates arrived at for changes of caribou intake (early May for the spring diet change and early December for the winter diet change), although not completely consistent with the change of seasons, are also not totally unreasonable.

The curve obtained for estimated average body burdens presented in figure 2, together with the observed measurements, shows the relatively close agreement between the actual values and the fitted equation. In only one instance (January 1964) did the estimated values differ from the measured values by more than 15 percent. This is also the one period for which data were lacking for the concentration of cesium–137 in caribou muscle. Since the effective half-life of cesium–137 in the individuals counted cannot be obtained from the data, equation 2 was fitted to the average body burden using various effective half-lives. Figure 2 is derived by using a value of 140 days which appeared to give the best fit. This value for the effective half-life in man, while somewhat greater than might at first be expected, is not grossly inconsistent with reported values (*19*).

It should not be implied that this value represents the actual effective half-life in the individuals concerned, it should be considered as a mathematical parameter that has been used to suitably represent the data.

At this point, it is important to discuss the effect of the assumption of a base level of 0.7 nCi/kg of cesium–137 in caribou flesh during the late summer and fall seasons. If this assumption is not valid, and actual levels in caribou, and thus the Eskimo's intake, were significantly higher, the method used would yield a fitted equation with a somewhat overestimated effective half-life. Thus, higher levels during these periods might tend to give an effective half-life somewhat closer to the 100-day value generally used.

In attempting to evaluate how reasonable our analysis and results are, some short discussion of the factor α in equation 2 is of interest.

In general α may be expressed as follows:

$$\alpha = \frac{cfw}{\lambda}$$

where: c = Proportionality factor
f = Fraction of cesium-137 ingested that is deposited in the body
λ = Effective decay constant (days^{-1})
w = Daily intake (kg/day)

solving for the daily intake w, yields

$$w = \frac{\alpha\lambda}{cf}$$

The value for α obtained from the fitted equation was 0.142. The fraction f is estimated to be 1.0 (*2, 21*). Using these values we can estimate the daily intake suggested by the observed value of α. The calculation yields a daily intake of 0.703 kg/day.

This value can be compared with the 0.772 (kg/day) value for caribou intake reported by Hanson *et al.* (*5*) as an estimate for the summer of 1962.

Conclusions

Although a number of generalizing assumptions have been made, it can be concluded that, on the basis of available data, the model devised yields reasonably accurate approximations to the observed data, and should allow anticipation of the resultant average body burdens in Anaktuvuk villagers on the basis of cesium-137 concentration in caribou muscle. It may also be concluded that expected body burdens will be somewhat lower in July and August of 1965 than those observed in July–August of 1964.

The average body burdens of the adult Anaktuvuk Pass villagers for the summer of 1965 is estimated to be approximately 0.9 μCi. At present it is not possible to say whether the apparent decreasing trend will continue. As more information on specific ecological factors becomes available, more accurate assumptions and further refinements in the model presented should be possible.

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DETECTION OF FRESH FISSION PRODUCT MATERIAL IN ENVIRONMENTAL SAMPLES FOLLOWING THE SECOND NUCLEAR DETONATION ON THE CHINESE MAINLAND

Division of Radiological Health, Public Health Service

On May 13, 1965 (10 p.m. EST) a second nuclear detonation occurred on the mainland of China. The test was believed to have taken place in the vicinity of Lop Nor in northwest China and was equal to or greater in yield than the first detonation that occurred in October 1964 (*1*). As with the first test, fresh fission products were observed by the Division of Radiological Health's routine environmental monitoring systems following the second test. The purpose of this summary is to report the extent to which fresh debris was observed in the Radiation Surveillance Network (RSN), the Pasteurized Milk Sampling Network (PMN) and the Bovine Thyroid Sampling Network of the Division of Radiological Health during May and June 1965.

Air

According to the 30,000 to 40,000-foot cloud trajectory developed by the Atmospheric Radioactivity Research Branch, United States Weather Bureau, the leading edge of the debris cloud passed the west coast of the United States on May 18 and the east coast by May 19 (*2*). Although early field estimates did not show any immediate significant increases in gross beta radioactivity, subsequent gamma analysis identified fresh fission products (iodine–132, tellurium–132, iodine–131, barium–140 and lanthanum–140) and the activation product neptunium–239 in many of the RSN's air samples.

The highest gross beta activity in air during the month of May for the United States was approximately 16 pCi/m^3 at Salt Lake City, Utah, for the sample collected May 20–21.

Fresh fission products were, however, first detected in the Helena, Montana, sample collected on May 18–19 (approximately 5 days after the detonation). Filters removed the following morning from most RSN stations in the Western United States contained identifiable fresh fission products in very low concentrations. The exceptions were those stations located on the Pacific coast. Except for the Pacific coast stations and several stations in the southeastern United States, at least one sample from each RSN station showed identifiable fresh fission products by May 24. From May 19–31, fresh fission products were identified on 87 RSN filters. During the month of June, fresh fission products were identified on 266 filters. In summary, the observation of the influx of fresh fission product material in air was generally consistent with the projected trajectory of the debris cloud, with the initial influx observed about May 18–20, and the peak air activity occurring somewhat later as might be expected.

Milk

Iodine–131 was not detected in any Pasteurized Milk Network (PMN) sample until May 24. However, since only one sample per week is routinely collected at each station, iodine–131 may have been present in milk several days prior to this date. Iodine–131 was detected on May 24 in only two samples; Honolulu, Hawaii, and Rapid City, South Dakota. Between May 24 and May 31, iodine–131 was found in measurable quantities in 19 samples from the PMN (*3*). During the month of June, 126 PMN samples contained detectable quantities of iodine–131 (page 539 of this issue). The highest concentration of iodine–131 observed was 220 pCi/liter for the sample collected on May 28 at Kansas City, Missouri.

Isograms showing the iodine–131 concentrations in milk for the weeks of May 23 and May 30 are shown in figures 1 and 2, respectively. The highest concentrations occurred in the Midwest, particularly in Missouri and Iowa. Only a few positive iodine–131 determinations were observed along the west coast and the southwestern and southeastern United States. By the end of June, iodine–131 was below detectable levels at most stations.

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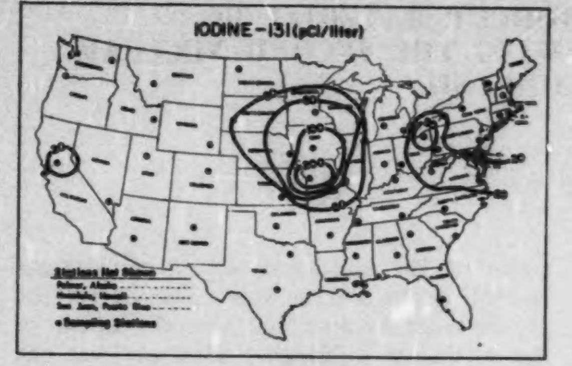
IODINE-131 (pCi/liter)
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
• Sampling Stations

Figure 1. Iodine-131 concentrations in pasteurized milk, May 23–29, 1965

Bovine thyroid

During the months of May and June 1965, iodine-131 was found in measurable quantities in approximately 500 bovine thyroids collected as part of the Division of Radiological Health Surveillance Program. The highest activity observed in a single thyroid was approximately 2,000 pCi/gram in a thyroid collected on June 8 in the State of Iowa. The average value for eight thyroids collected in Iowa on this day was 821 pCi/gram.

Because of the relatively small number of thyroids collected on any one day in any single area, it is difficult to relate the levels of iodine in thyroid to the changing levels of iodine observed in other environmental media. However, the data may be grouped to show general trends following the influx of iodine-131 into the environment. Figures 3, 4, and 5 show the weekly average levels of iodine-131 in bovine thyroids for several grouped States. The data for California have been plotted separately in order to show the relative sensitivity of the bovine thyroid as an indicator of environmental iodine-131. Although only one milk sample collected in California by the PMN showed measurable iodine-131, the low level intrusion was readily documented by the bovine thyroid analysis. In general, the observations of iodine-131 in bovine thyroids were consistent with observations of iodine-131 in milk. The highest average levels were observed in the Midwest and lowest average levels in California.

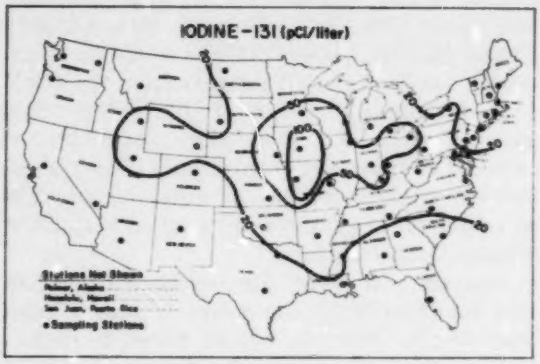
IODINE-131 (pCi/liter)
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
• Sampling Stations

Figure 2. Iodine-131 concentrations in pasteurized milk, May 30–June 5, 1965

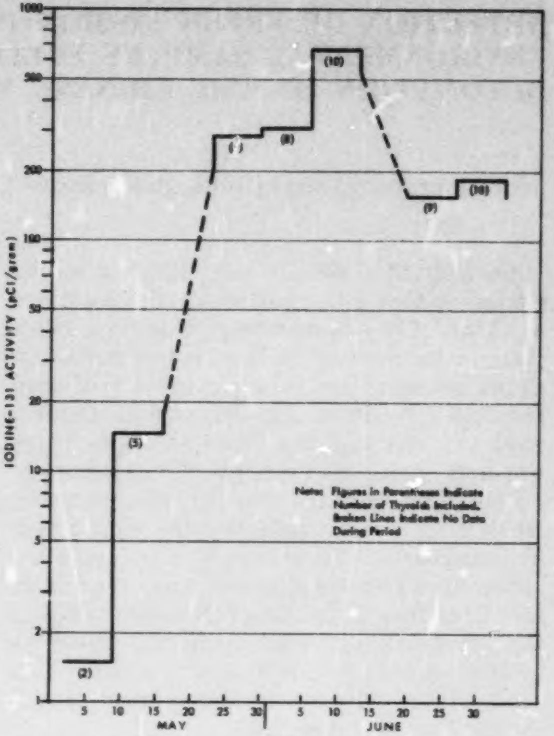

Figure 3. Weekly average levels of iodine-131 in bovine thyroids from South Dakota and Iowa, May–June 1965

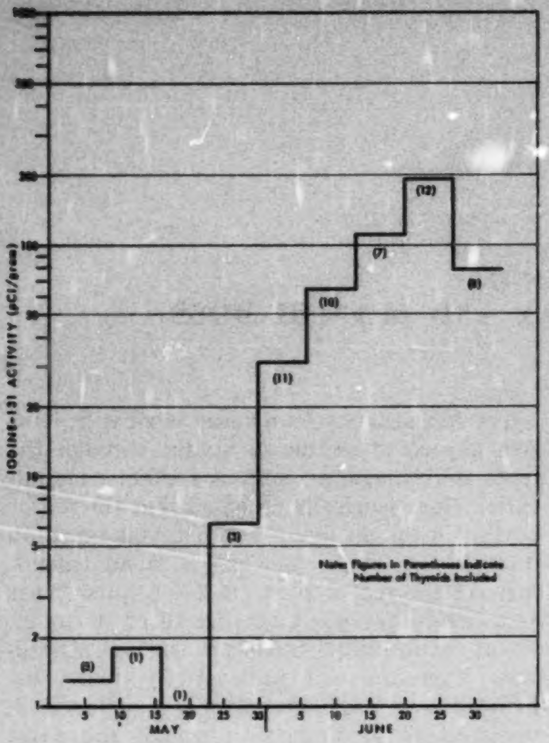

Figure 4. Weekly average levels of iodine–131 in bovine thyroids from California, May–June 1965

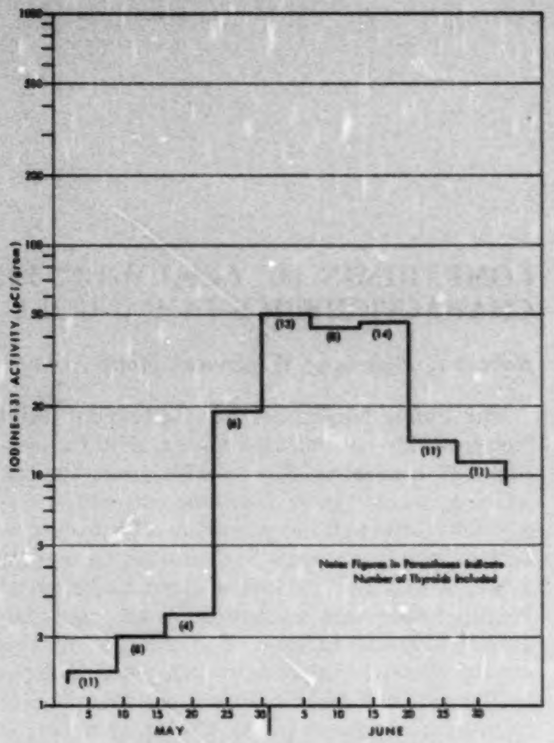

Figure 5. Weekly average levels of iodine–131 in bovine thyroids from New Mexico, Texas, and Colorado, May–June 1965

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COMPARISON OF CESIUM-137 BINDING CHARACTERISTICS IN PANGOLA HAY AND SPANISH MOSS

Robert L. Elder and Wellington Moore, Jr.[1]

The Public Health Service Pasteurized Milk Network has consistently shown that the cesium–137 concentrations in milk from Tampa, Florida, were higher than the national average (*1*). Although not requiring any protective actions, the levels were high enough to prompt a field survey by the Southeastern Radiological Health Laboratory to determine the contributory ecological factors. The results of this survey showed that cesium–137 concentrations in Pangola hay and Spanish moss were higher than in other plants in the Tampa area (*2*). It was further shown that elimination of Pangola hay from the diet of dairy cows in the Tampa area resulted in a decrease in the amount of cesium–137 in the milk (*2*). Having isolated Pangola hay as a factor contributing to the observed cesium–137 concentrations, analyses were undertaken to determine binding characteristics involved. For this purpose, Pangola hay was compared to Spanish moss. Pangola hay is a rooted grass grown in the Southern States, particularly Florida. Spanish moss is a non-rooted plant and is not routinely used as a dairy cattle feed.

The identification and isolation of particular types of vegetation which introduce high amounts of radioactivity into the food chain of animals and man is required. However, the presence of high levels of radioactivity in a plant that is used in the food chain does not necessarily constitute a direct hazard. The introduction into the food chain requires both presence and release during the process of digestion and absorption.

The radioactivity found associated with Pangola hay could be due to uptake through the roots and foliage, or exist as surface contamination. It is generally accepted that the major portion of the cesium–137 in plants is taken up through the leaves, and only a small amount through the root system (*3, 4*). Spanish moss as a non-rooted plant obtains all of its nutritional requirements by direct surface absorption. Therefore, all radioactivity found associated with this plant exists as a surface contaminant or is absorbed through the plant surface. In these preliminary studies we compared the location, binding and release of radioactive fallout particles from these two plants.

Procedures

(a) The Pangola hay was obtained from a farm located in the Tampa, Florida area. The Spanish moss was collected in the vicinity of Montgomery, Alabama.

(b) *Water washing*—Light water washing was accomplished by lightly spraying uncut hay or moss with water for three hours. Submerged water washing was done following cutting, grinding in a blender, and sifting through 18- x 14-mesh screen. The object of this grinding was to destroy as much of the plant cell structure as possible. A 500 gram sample was submerged and soaked in 3.5 liters of water for two hours. The samples were then filtered through Whatman 40 filter paper, and the wash water was passed back over the sample four times. The samples were air dried at room temperature to correspond to the unwashed samples.

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[1] Dr. Elder is a research staff officer and Dr. Moore is Chief, Research Unit, Southeastern Radiological Health Laboratory, P.O. Box 61, Montgomery, Alabama.

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(c) *Counting*—A multichannel gamma spectrometer was used for all counting. The large vegetative samples were counted with a 4- x 4-inch sodium iodide crystal and a 1- x 1-inch crystal was used for the isotope studies.

(d) *Ionic isotope binding*—Each sample was cut, ground and sifted through an 18- by 14-mesh screen. The samples were thoroughly washed and packed in 1- x 5-inch columns with fritted glass filters. The isotopic solution was applied directly to the top of the packed column followed by 100 ml of distilled water, which was collected at 5 ml intervals. Following the water elution a 100 ml KCl gradient (0–.5N) elution was applied and collected at 5-ml intervals.

Results

The results in table 1 indicated that a light water washing (equivalent to a heavy rain) removed 66 percent of the cesium–137 from Pangola hay, but less than 10 percent of the cesium–137 from Spanish moss. Similar results are presented in table 2 for the submerged water washing of ground samples. These results indicated that practically all of the cesium–137 on Pangola hay existed as a surface contaminant. The higher percent removal of cesium–137 in the submerged washing of Spanish moss was due most likely to the breakdown of cell structure by the grinding process.

The cerium–144 and ruthenium–106 levels for Pangola hay were below detectable limits. Both of these nuclides were found in much higher concentrations in Spanish moss and were not substantially released by either washing process.

Managanese–54 was found in both Pangola hay and Spanish moss. Light washing did not remove this nuclide from either plant (table 1). However, the submerged washing of ground samples showed a substantial reduction of this nuclide from both plants (table 2). Again it appeared that this removal was due to a breakdown of the cell structure during the grinding process. This would facilitate the release of internally bound nuclides in contast to surface bound contaminants.

Attempts to increase the efficiency of radionuclide removal by washing both plants with a 0.5N KCl solution did not substantially change the results (table 2). These findings indicated that Spanish moss had a very active inorganic ion binding mechanism. This is further supported by water washing results discussed in the preceding paragraph.

However, the cesium–137 of Pangola hay appeared to be almost totally on the surface of the plant. In the latter case any active binding is at best quite weak, for a considerable amount of this nuclide was removed by light washing.

The results of further studies to demonstrate the nature and site of the inorganic ion binding

Table 1. Removal of radioactive fallout by light water washing

	Cesium-137					Cerium-144			
	Pangola hay		Spanish moss			Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining		pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	3,100	100	2,480	100	Unwashed	<15	—	1,385	100
Washed	1,070	34	2,260	91	Washed	<15	—	1,275	92

	Ruthenium-106					Manganese-54			
	Pangola hay		Spanish moss			Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining		pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	<15	—	1,300	100	Unwashed	983	100	1,000	100
Washed	<15	—	1,220	94	Washed	925	94	815	81

Table 2. Removal of radioactive fallout by submerged water washing

Cesium-137	Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	3,100	100	2,260	100
0.5N KC1 Washed 1 x	1,030	33	1,360	60
Water Washed 1 x	977	31	1,490	66
Water Washed 2 x	472	15	1,070	48

Cerium-144	Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	<15	—	1,275	100
0.5N KC1 Wash 1 x	<15	—	942	74
Water Washed 1 x	<15	—	925	73
Water Washed 2 x	<15	—	845	66

Ruthenium-106	Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	<15	100	1,220	100
0.5N KC1 Washed 1 x	<15	0	1,060	87
Water Washed 1 x	<15	0	1,100	90
Water Washed 2 x	<15	0	934	76

Manganese-54	Pangola hay		Spanish moss	
	pCi/kg	Percent remaining	pCi/kg	Percent remaining
Unwashed	441	100	815	100
0.5N KC1 Washed 1 x	260	59	367	45
Water Washed 1 x	265	60	386	47
Water Washed 2 x	115	25	220	27

in these two plants are shown in figures 1 and 2. When either cesium-137 or strontium-85 in aqueous solution is added to ground Spanish moss or Pangola hay it cannot be removed by water washing. Following the addition of a gradually increasing concentration of a KCl solution, complete removal of the added isotope occurred. Thus, Spanish moss did not appear to have an active binding mechanism when the cell structure is damaged. Ground samples of both Spanish moss and Pangola hay acted as a simple ion exchange system.

Summary and conclusion

These preliminary studies indicate that most of the cesium-137 exists on Pangola hay as a lightly bound surface contaminant. This conclusion is supported by the effective removal of cesium-137 by the water washing, and the poor elution of the more tightly bound Manganese-54 without damaging the cell walls. In contrast to this, Spanish moss very tightly

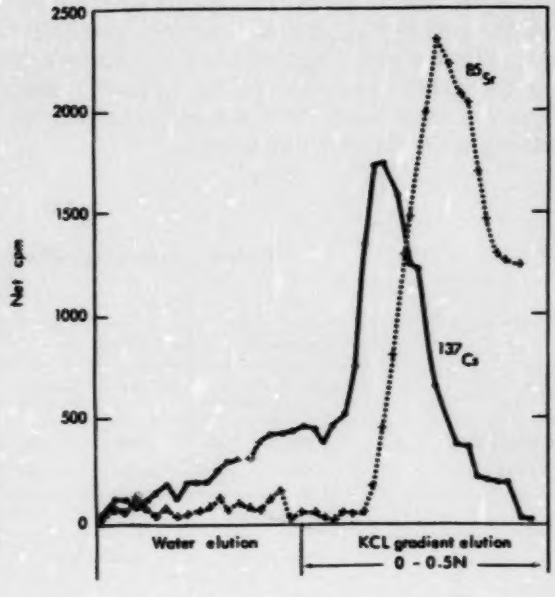

Figure 1. Elution of radionuclides from Pangola hay

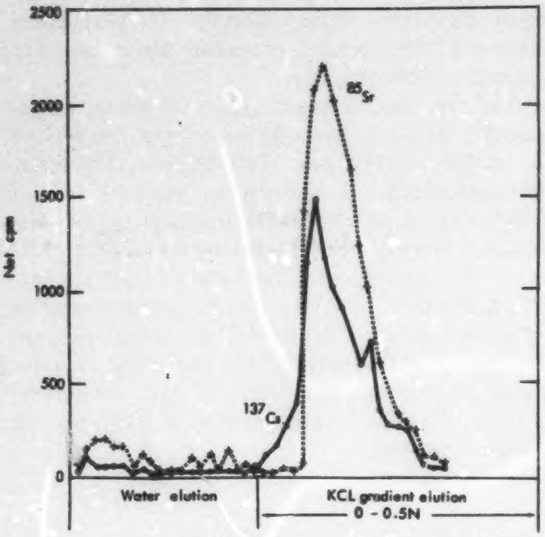

Figure 2. Elution of radionuclides from Spanish moss

binds all of the isotopes detected. When these isotopes settle from the air onto Spanish moss they are actively bound and incorporated into the plant structure. Ionic washing (0.5 KCl) did not remove these nuclides.

When the cell structure of Spanish moss and Pangola hay was damaged by grinding, neither plant actively bound cesium–137 nor strontium –85. The ground material from both plants was comparable to a simple ion exchange system. Thus one is led to conclude that the nuclide binding and uptake of radioisotopes by Spanish moss requires an intact cell structure.

These results have been presented to demonstrate the difference in location and binding of radioactive fallout isotopes. Spanish moss actively binds and retains airborne radioactive isotopes. These radioactive elements are most likely internally bound. Pangola hay has been shown to be high in cesium–137, but this exists as a surface contaminant. If Pangola hay has an active binding mechanism during growth, it appears to be only a surface binding and is lost following cutting and drying.

REFERENCES

(*1*) DIVISION OF RADIOLOGICAL AND OCCUPATIONAL HEALTH, FLORIDA STATE BOARD OF HEALTH. Florida milk network, 1963. Rad Health Data 5:477–478 (October 1964).

(*2*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The cause of relatively high cesium–137 concentrations in Tampa, Florida, milk. (To be published.)

(*3*) NISHITA, H. and K. H. LARSON. Summary of certain trends in soil-plant relationship studies of biological availability of fallout debris. U.S. Atomic Energy Commission Report UCLA–401 (July 1957).

(*4*) MIDDLETON, L. J. Absorption and translocation of strontium and cesium by plants from foliar sprays. Nature 181:1300 (1958).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for the Bettis Atomic Power Laboratory, Feed Materials Production Center, Knolls Atomic Power Laboratory, and SIC Prototype Reactor.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentration limits, are applicable to effluents released from AEC installations.

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Bettis Atomic Power Laboratory[2]
July–December 1964

Western Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pennsylvania. Routine environmental monitoring data from the sampling locations shown in figure 1 indicate that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits.

Liquid radioactive waste

Liquid effluent discharged from the Laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta–gamma activity and quaterly for strontium–90 activity. In addition, analysis for total uranium alpha activity is performed whenever the combined gross alpha activity exceeds 2,000 pCi/liter.

The average concentration of gross radioactivity in the liquid effluent during the second 6 months of 1964 was 180 pCi/liter. The average concentration observed in the first half of 1964 was 53 pCi/liter. During this period, the highest weekly concentration was 2,000 pCi/liter. The average concentration of strontium–90 in the liquid effluent for the second quarter of 1964 was 3.5 pCi/liter. The average concentration of strontium–90 for the third quarter of 1964 was 8.1 pCi/liter. The strontium–90 analysis for the fourth quarter of 1964 has not been completed.

Background monitoring stations

Three background monitoring stations are in continuous operation near the Laboratory. These stations continually measure and record the external beta–gamma radiation level. Average readings at these stations are summarized in table 1.

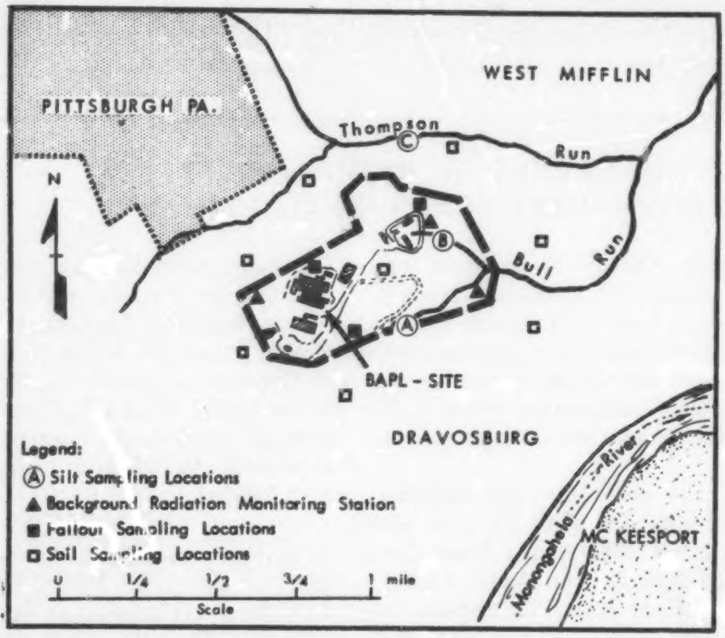
WEST MIFFLIN
PITTSBURGH PA.
Thompson
Run
N
Bull
Run
Ⓒ
Ⓑ
Ⓐ
BAPL - SITE
DRAVOSBURG
Monongahela
River
MC KEESPORT
Legend:
Ⓐ Silt Sampling Locations
▲ Background Radiation Monitoring Station
■ Fallout Sampling Locations
□ Soil Sampling Locations
0
1/4
1/2
3/4
1 mile
Scale

Figure 1. Bettis Atomic Power Laboratory sampling stations

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[2] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the Second Six Months of 1964 and for Calendar Year 1964" (PNRO–DEV–132).

Table 1. Beta-gamma radiation, July–December, 1964

(Average levels in mR/hr)

Station	1	3	4
High weekly level	0.035	0.018	0.209
Low weekly level	0.010	0.010	0.049
Mean	0.014	0.012	0.061

Beta-gamma radiation intensities averaged 0.029 mR/hr during this period. This average represents an increase over the average intensity measured during the first 6 months of 1964, which was 0.016 mR/hr. The increase in the mean beta-gamma activity at Station #4 is due to the proximity of the environmental monitoring detector to the C-Area Critical Facility. During critical operations, the beta-gamma background activity increases and is readily discernible over the periods of reactor shutdown. Normal background levels average from 0.010 to 0.060 mR/hr during reactor shutdown and from 0.8 to 1 mR/hr during reactor operation.

Fallout

Fallout samples are collected at three locations at the perimeter of the Laboratory. Samples are collected over a period of one month in high-wall stainless steel pots, and are analyzed for gross beta activity. The average monthly concentration of radioactive fallout for the second half of 1964 was 3.59 nCi/m². This was a decrease from the 8.61 nCi/m² recorded during the first 6 months of the year.

Soil samples

Soil samples were collected at the eight locations shown in figure 1. None of these samples required analysis, according to the provisions of the operating manual, PNRO–DEV–122.

Stream silt

Soil samples were collected at the eight locations shown in figure 1. The results of analysis of these samples are presented in table 2.

Table 2. Radioactivity in stream silt, July–December 1964

Period	Location	Alpha, pCi/g	Beta-gamma pCi/g
Third quarter, 1964	A	21	22
	B	14	30
	C	27	19
	Average	21	24
Fourth quarter, 1964	A	16	27
	B	27	19
	C	28	12
	Average	24	19

Recent coverage in *Radiological Health Data:*

Period	Issue
July 1961 to June 1962	*April 1963*
July 1962 to June 1963	*April 1964*
July 1963 to December 1963	*November 1964*
January–June 1964	*April 1965*

2. Feed Materials Production Center[3] July–December 1964

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the Center. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium, and with fabricating the metal into fuel elements.

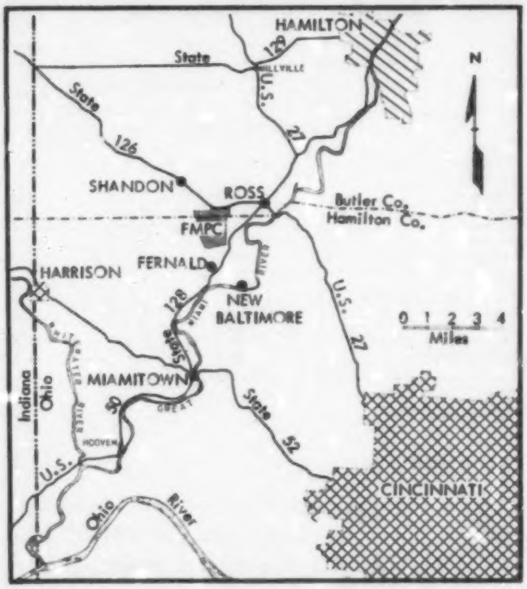

Figure 2. Area map of Feed Materials Production Center

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[3] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1964 and Summary Report for 1964" (NLCO–939).

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that releases of radioactive materials to the environment are within AEC and State of Ohio standards.

Air monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers which remove nearly all of the airborne particulates generated during the many plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 3.

Table 3. Radioactivity levels of airborne particulates, July–December 1964

(Average concentrations in pCi/m³)

Location	Second half 1964		
	No. of samples	Uranium [a]	Total activity [b]
Onsite			
Southwest	26	0.2	0.8
Northwest	26	0.1	0.5
Northeast	26	0.2	0.7
Southeast	26	0.1	0.6
All onsite samples	104	0.2	0.7
Offsite			
0–2 miles from FMPC	26	0.1	0.6
2–4 miles from FMPC	22	0.1	0.5
4–8 miles from FMPC	30	0.1	0.5
8–10 miles from FMPC	10	0.1	0.3
All offsite samples	88	0.1	0.5

[a] MPC = 2 pCi/m³.
[b] MPC = 100 pCi/m³.

Water monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken at the locations shown in figure 3.

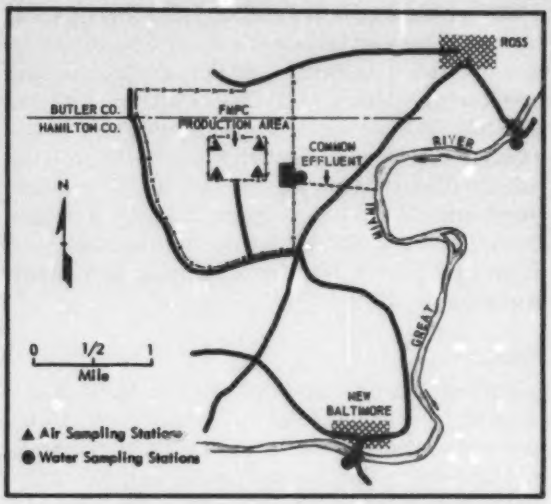

Figure 3. Air and water sampling stations, Feed Materials Production Center

Table 4 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference of the upstream and downstream measurements.

Table 4. Concentrations of uranium and total activity in the Great Miami River, Ohio, July–December 1964

(Average concentrations in pCi/liter)

Location	Method of determination	Second half 1964		
		Number of samples	Uranium [a]	Total activity [b]
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	184	12	20
Upstream	Spot samples	26	5	30
Downstream	Spot samples	30	7	30
Difference		—	2	0

[a] MPC = 20,000 pCi/liter.
[b] MPC = 3,000 pCi/liter.

Recent coverage in *Radiological Health Data:*

Period	Issue
July–December 1960	*June 1961*
January–June 1961	*December 1961*
July 1961–June 1962	*March 1963*
July 1962–December 1963	*May 1964*
January–June 1964	*April 1965*

3. Knolls Atomic Power Laboratory[4]
July–December 1964

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Atomic Energy Commission in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site, and the West Milton site, located as shown in figure 4. The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; and critical assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facility. Regular environmental monitoring activities are conducted to assure that Laboratory releases of radioactivity to the environment are in compliance with AEC standards. The data that follow indicate that Laboratory waste operations have complied with AEC requirements.

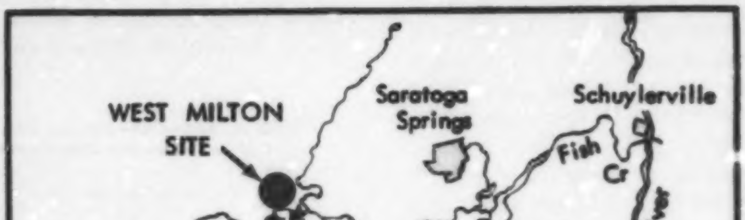
WEST MILTON SITE
Saratoga Springs
Schuylerville
Fish Cr
River
Glowegee Creek
Saratoga Lake
Ballston Spa
Amsterdam
Mohawk River
Scotia
Vischer's Ferry
Cresent Dam
SCHENECTADY
Cohoes
N
TROY
KNOLLS SITE
ALBANY
Hudson
0 5 10 Miles
★ Water sampling stations

Figure 4. Environmental monitoring locations, KAPL

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[4] Summarized from "Knolls Atomic Power Laboratory Semiannual Environmental Monitoring Report, July–December 1964" (Volume 6, Number 2).

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory, approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The results of the airborne radioactivity analyses are given in table 5. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the naturally occurring short-lived materials to decay.

Table 5. Airborne beta activity, KAPL, July–December 1964

Sampling locations	Concentrations, pCi/m^3
Knolls site	0.33
West Milton site	0.38
Research Laboratory	0.33

Liquid waste monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to (1) the concentration of fission products in the collection tanks, and (2) the flow of the river. A continuous proportional sample of the Knolls site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principal component to be considered in control. The amounts and the radionuclide content of the combined sewer effluent discharged from the Knolls site have been summarized in table 6.

Table 6. Radionuclide concentrations in the Knolls site waste effluent, July–December 1964

(Average concentrations in pCi/liter)

Radionuclides	Concentrations	AEC Standards
Strontium-89	4.1	3,000
Strontium-90	120	300
Cesium-137	240	20,000
Cerium-144—Praseodymium-144	37	10,000
Ruthenium-106	4.1	10,000
Iodine-131	4.1	300

A total of 93.0 millicuries of beta activity was discharged to the Mohawk River during the 6–month period at monthly average concentrations ranging from 230 to 770 pCi/liter.

Since Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of .1 millicuries was discharged at two points into Glowegee Creek during the six–month period at monthly average concentrations ranging from 245 to 336 pCi/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Mohawk River water is sampled continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse eight miles upstream from the site; at the Visher Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results are given in table 7.

Table 7. Gross beta-gamma activity in streams receiving effluents, July–December 1964

Streams and locations	Concentrations, pCi/liter
Mohawk River (Knolls site):[a]	
G.E. Powerhouse (upstream)	6
Vischer Ferry (downstream)	4
Cohoes (downstream) raw-water	5
Cohoes (downstream) finished drinking water	5
Glowegee Creek (West Milton site):[a]	
Upstream	13
Downstream	15

[a] MPC 100 pCi/liter.

Recent coverage in *Radiological Health Data:*

Period	Issue
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1962–December 1963	*June 1964*
January–June 1964	*April 1965*

4. S1C Prototype Reactor Facility[5] July–December 1964

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land-based nuclear submarine power plant facility containing a pressurized water reactor power plant which is used for research, development, and training. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations. Monitoring results which follow indicate that the Facility has fully complied with the prescribed standards of the AEC.

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 8 and 9 give the average beta concentrations of airborne and liquid wastes before release to the environment.

Table 8. Airborne beta activity, S1C July–December 1964

Sampling locations	Concentrations, pCi/m³
Stack discharge	46
Onsite average	0.41
Offsite average	0.53

Table 9. Radioactivity in liquid wastes discharged into the Farmington River, S1C, July–December 1964

Activity	Quantity
Total beta activity (millicuries)	9.2
Average gross beta concentrations (pCi/liter):	2,100
Cobalt-60	1,900
Iron-59	72
Manganese-54, Cobalt-58	230

Figure 5 shows the locations of 6 water sampling stations along the Farmington River and of 17 fallout monitoring stations. Comparisons of the data for upstream and downstream water and mud samples showed no significant difference from background during the period reported. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of *Radiological Health Data.*

Recent coverage in *Radiological Health Data:*

Period	Issue
January–July 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1963–December 1963	*June 1964*
January–June 1964	*April 1965*

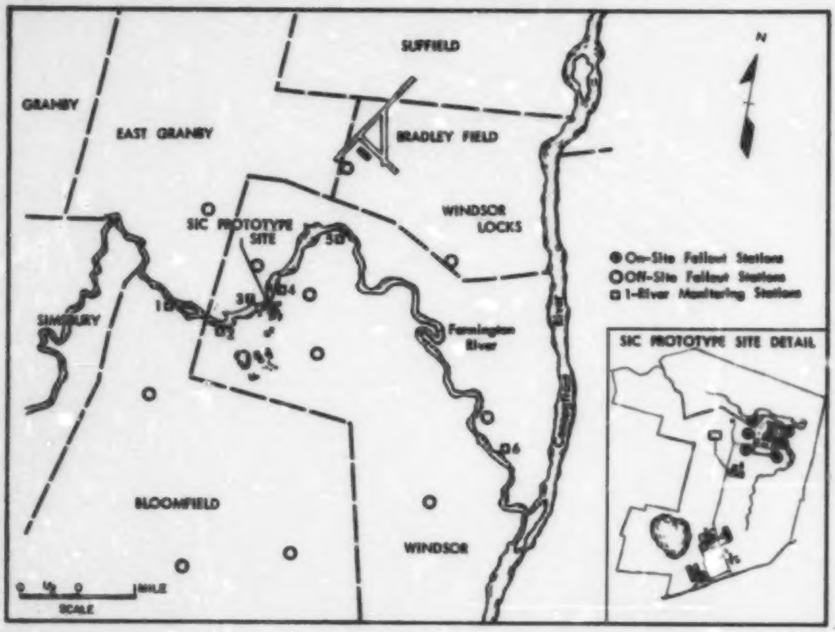
SUFFIELD
GRANBY
EAST GRANBY
BRADLEY FIELD
WINDSOR LOCKS
SIC PROTOTYPE SITE
N
● On-Site Fallout Stations
○ Off-Site Fallout Stations
□ 1-River Monitoring Stations
SIMSBURY
1
2
3
4
5
6
Farmington River
SIC PROTOTYPE SITE DETAIL
BLOOMFIELD
WINDSOR
0 ½ 0 1 MILE
SCALE

Figure 5. Environmental monitoring locations, S1C Prototype Site

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[5] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, July 1 to December 31, 1964" (CENRD-3163-RS-499).

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REPORTED NUCLEAR DETONATIONS

During September 1965 the Atomic Energy Commission announced two nuclear tests of low yield (under 20 kilotons) conducted underground on September 1 and on September 17, 1965 at the Nevada Test Site. In addition, a low-yield test conducted in an underground cavity in rock on June 17, 1965, also at the Nevada Test Site, was announced. Data from this test will be used in connection with a program to improve means of detecting underground nuclear detonations.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Synopses of contributed articles are presented below in reference card format for the reader's convenience.

RADIOCARBON IN SURFACE AIR. *Drobinski, J. C., Jr.* (Division of Radiological Health, USPHS). Radiological Kealth Data, Vol. 6, November 1965, pp. 605–606.

Increasing carbon-14 levels were observed in surface air by radioanalysis of its carbon dioxide content during the period January 1964 to April 1965. Most of the increase was noted in March 1964.

CESIUM-137 IN FRESHWATER FISH: CONSUMPTION AND BODY BURDEN CONSIDERATIONS. *Gustafson, P. F.* (Argonne National Laboratory). Radiological Health Data, Vol. 6, November 1965, pp. 626–630.

Recent measurements of cesium-137 in freshwater fish purchased in the Chicago area indicate, on a unit mass basis as well as in terms of the ^{137}Ca/K ratio, that such fish contain substantially higher levels than do the dietary staples such as milk, meat, and grain products. These observations are discussed in terms of the resulting human intake of this radionuclide, and the author indicates that there is strong suggestive evidence that body burdens of the order of 0.1 μCi could be attained under certain circumstances. From the scientific point of view, these observations should be considered both for their radiological health implications and for the opportunity such levels offer for detailed field studies of the freshwater eco-system.

FALLOUT RADIONUCLIDES IN MILK, TOTAL DIET, AND HUMAN BONE COMPARED TO FEDERAL RADIATION COUNCIL ESTIMATES, 1963–1964. *Grundy, R. D., R. P. Chandler, J. R. Coleman, and J. G. Terrill, Jr.* (Division of Radiological Health, USPHS). Radiological Health Data, Vol. 6, November 1965, pp. 661–665.

The estimates made in Federal Radiation Council Reports, numbers 4 and 6, regarding the maximum concentrations of radionuclides in the environment and man, have been essentially verified by recent surveillance data. The peak intake of radionuclides by the population groups selected appears to have occurred in 1964. It is concluded that the FRC predictions and the radiation doses projected over the next 30 and 70 years are valid and reasonable for the situation as it exists today.

RADIOACTIVE CERAMIC GLAZES. *Menczer, L. F.* (Health Department, Harford, Connecticut). Radiological Health Data, Vol. 6, November 1965, pp. 656–659.

A number of pre-1940 items of ceramicware containing uranium ore pigments were examined by film-badge technique. This study obtained some substantially higher beta and gamma readings than those previously reported by other investigators. The range of exposure to the hands was estimated (on the basis of a 1½ hour daily exposure) to be 2.9 to 10.3 rems for a 50-week period.

Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity from fallout. Although this surveillance does not provide enough information to assess human radiation exposure, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network
July 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators report (by telephone) field estimates greater than 10 pCi/m^3 (except for Hawaii, Alaska, and Puerto Rico, which report 5 pCi/m^3) to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Field estimates and laboratory measurements of daily concentrations and the estimated ages for selected samples are reported in the monthly RSN report (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Sampling and analytical procedures

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1,800 cubic meters of air are drawn through a filter during the 24-hour sampling period. The filters are forwarded to the RSN laboratory in Rockville, Maryland, where the gross beta activity is measured 4 days after the sampling period and again 7 days later if the net count is 2,000 cpm or higher. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated and the activity at time of collection determined.[1]

The total precipitation is sampled continuously at most RSN stations on a daily basis,

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[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

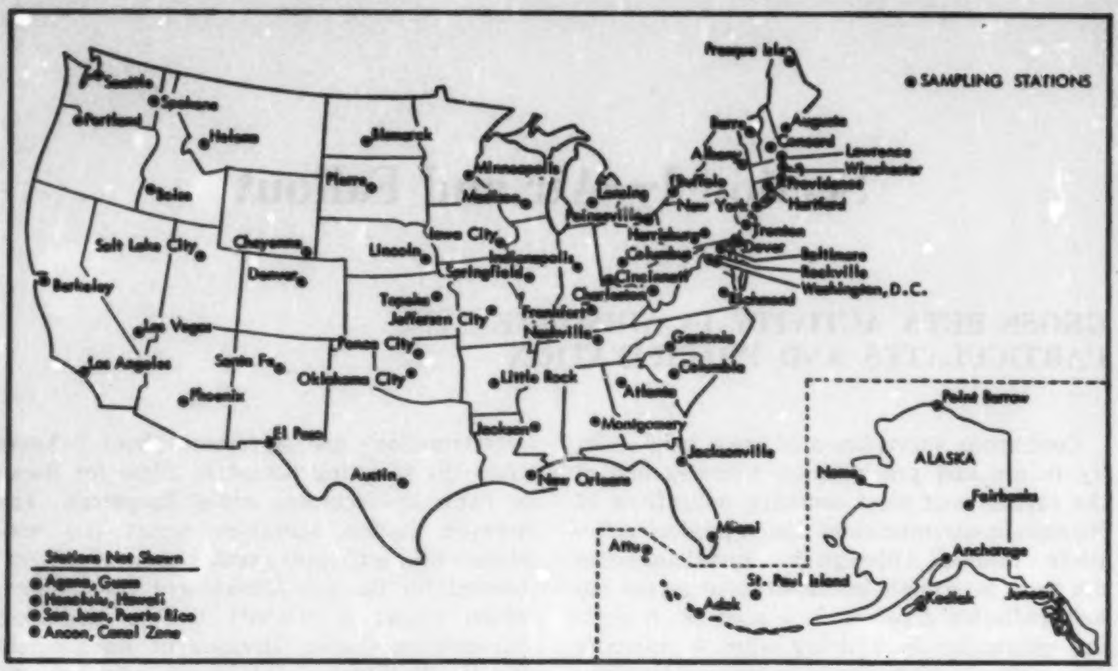
Presque Isle
SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Bismarck
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Minneapolis
Pierre
Madison
Lansing
Buffalo
New York
Boise
Painesville
Trenton
Harrisburg
Iowa City
Salt Lake City
Cheyenne
Lincoln
Indianapolis
Columbus
Dover
Baltimore
Rockville
Washington, D.C.
Springfield
Cincinnati
Berkeley
Denver
Topeka
Charleston
Richmond
Jefferson City
Frankfort
Nashville
Las Vegas
Ponca City
Gastonia
Los Angeles
Santa Fe
Columbia
Oklahoma City
Little Rock
Atlanta
Phoenix
Point Barrow
Montgomery
El Paso
Jackson
ALASKA
Jacksonville
Nome
Austin
New Orleans
Fairbanks
Miami
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

Figure 1. Radiation Surveillance Network Sampling Stations

using funnels with collection areas of 0.4 square meter. If the rainfall exceeds 0.2 inch, the precipitation sample is analyzed for gross beta activity (*1*). Additionally, analyses for specific radionuclides may be performed.

In the laboratory the gross beta activity in evaporated precipitation samples is calculated by the same method used for analyzing the air filters. Total deposition for the sample is determined by:

$$\text{Deposition (nCi/m}^2\text{)} = \frac{\text{concentration (pCi/liter)} \times \text{precipitation depth (mm)}}{1{,}000}$$

Selected air and precipitation samples are analyzed by gamma spectrometry to determine the presence of fresh fission products. The method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the complex gamma spectra.

Results

Monthly values of gross beta activity in air, total deposition, and depth of precipitation are given in table 1 for July 1965. During this month, the RSN collected 1,946 air samples and 332 precipitation samples. Forty-seven air samples were analyzed by gamma spectrometry. Although trace quantities of ^{140}Ba–La (below 1 pCi/m^3) were observed, no traces of other fisson products were apparent.

Time profiles of gross beta activity in air for eight stations are shown in figure 2.

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Table 1. Gross beta activity in surface air and precipitation, July 1965

Station location		Air surveillance						Precipitation measurements	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD*	Total depth (mm)	Total deposition [b] (nCi/m²)
		Air	Pptn	Maximum	Minimum	Average [a]			
Ala:	Montgomery	31	8	0.40	<0.10	<0.15	May 65	130.5	<26.2
Alaska:	Adak	21		0.14	<0.10	<0.10	Sep 65	NS	
	Anchorage	29	10	0.27	<0.10	<0.12	May 65	38.4	<7.8
	Attu	17		0.10	<0.10	<0.10	Oct 65	NS	
	Fairbanks	27	4	0.24	<0.10	<0.14	Jun 65	31.9	<5.2
	Juneau	30	8	0.22	<0.10	<0.11	Jul 65	83.2	<16.8
	Kodiak	5		0.10	<0.10	<0.10	Aug 65	NS	
	Nome						Feb 65		
	Point Barrow	31		0.28	<0.10	<0.11	Nov 65	NS	
	St. Paul	19		0.11	<0.10	<0.10	Mar 65	NS	
Ariz:	Phoenix	[illegible]		0.37	<0.10	<0.14	Jul 65	NS	
Ark:	Little Rock	30	7	0.27	<0.10	<0.17	Jun 65	87.4	<17.5
Calif:	Berkeley	18		0.35	<0.10	<0.14	Aug 65	NS	
	Los Angeles	30		0.29	<0.10	<0.14	Feb 65	NS	
C. Z:	Ancon	14		0.18	<0.10	<0.11	Aug 65	NS	
Colo:	Denver	28	4	0.46	<0.10	<0.18	Aug 65	36.5	<7.4
Conn:	Hartford	30	5	0.63	<0.10	0.26	Jul 65	37.0	<20.3
Del:	Dover	19		0.82	<0.10	<0.37	May 65	NS	
D. C:	Washington	28	7	0.72	<0.10	<0.33	Nov 65	100.5	<20.1
Fla:	Jacksonville	31	10	0.35	<0.10	<0.15	Jun 65	175.2	<35.1
	Miami	29	13	0.30	<0.10	<0.13	Jul 65	168.2	<33.7
Ga:	Atlanta	8		0.25	<0.10	<0.14	Apr 65	NS	
Guam:	Agana	29		0.24	<0.10	<0.11	Apr 65	NS	
Hawaii:	Honolulu	31	6	0.14	<0.10	<0.10	Oct 65	58.1	<12.1
Idaho:	Boise	31		0.48	<0.10	0.24	Oct 65	NS	
Ill:	Springfield	31	1	0.76	0.12	0.28	Nov 65	13.5	<2.5
Ind:	Indianapolis	23	6	0.59	0.16	0.29	Apr 65	42.6	<8.7
Iowa:	Iowa City	30	6	0.59	0.13	0.25	Aug 65	61.0	<12.1
Kans:	Topeka	30	4	0.59	<0.10	0.21	May 65	73.3	<14.8
Ky:	Frankfort	27	7	0.66	<0.10	0.29	Nov 65	50.0	<10.1
La:	New Orleans	31	13	0.34	<0.10	<0.13	Nov 65	150.1	<30.4
Maine:	Augusta	30	7	0.81	<0.10	<0.34	Mar 65	47.0	<9.4
	Presque Isle	27	4	0.68	<0.10	<0.26	Aug 65	65.8	<13.2
Md:	Baltimore	21	3	1.06	<0.10	0.28	Jul 65	20.1	<4.0
	Rockville	19		0.88	<0.10	<0.25	Oct 65	NS	
Mass:	Lawrence	30	8	0.67	[illegible]	[illegible]	May 65	66.6	<16.9
	Winchester	28	5	0.60	<0.10	<0.26	Sep 65	24.8	<5.9
Mich:	Lansing	31	4	[illegible]	<0.10	0.31	Oct 65	9.6	<2.0
Minn:	Minneapolis	21	7	0.53	<0.10	0.21	Apr 65	98.4	<19.6
Miss:	Jackson	16	2	0.26	<0.10	<0.15	Dec 64	56.8	<11.4
Mo:	Jefferson City	31	9	0.47	<0.10	0.23	[illegible] 65	66.3	<13.8
Mont:	Helena	30	7	0.71	<0.10	[illegible]	Sep 65	17.6	<4.6
Nebr:	Lincoln	14	5	0.61	<0.10	<0.27	Mar 65	161.2	<32.3
Nev:	Las Vegas	29		0.50	<0.10	<0.20	Jun 65	NS	
N. H:	Concord	21		1.08	<0.10	0.38	Nov 65	NS	
N. J:	Trenton	30	4	0.77	<0.10	<0.27	Mar 65	26.6	<5.3
N. Mex:	Santa Fe	26	8	0.13	<0.10	<0.11	Sep 65	30.1	<6.1
N. Y:	Albany	21	7	0.57	<0.10	0.32	Apr 65	49.6	<9.9
	Buffalo	31		0.71	<0.10	0.29	Aug 65	NS	
	New York	29		0.56	<0.10	<0.24	Sep 65	NS	
N. C:	Gastonia	30	8	0.56	<0.10	<0.17	Aug 65	131.6	<26.5
N. Dak:	Bismarck	30	11	0.53	<0.10	<0.34	Nov 65	107.8	<21.6
Ohio:	Cincinnati	6		0.17	<0.10	<0.12	May 65	NS	
	Columbus	29	6	1.03	0.13	0.37	Mar 65	110.8	<22.1
	Painesville	24	4	0.89	<0.10	0.34	Jul 65	61.0	<12.2
Okla:	Oklahoma City	30	2	0.23	<0.10	<0.14	Oct 65	50.0	<10.0
	Ponca City	30	7	0.21	<0.10	<0.11	Jul 65	136.3	<27.6
Ore:	Portland	31	3	0.69	<0.10	<0.33	Mar 65	6.9	<1.4
Pa:	Harrisburg	30	1	0.65	<0.10	<0.24	Apr 65	6.0	<1.2
P. R:	San Juan	31	4	0.25	<0.10	<0.12	Mar 65	93.0	<18.5
R. I:	Providence	30	5	0.73	<0.10	<0.20	Oct 65	48.4	<9.7
S. C:	Columbia	24	13	0.61	<0.10	<0.16	Sep 65	225.6	<45.2
S. Dak:	Pierre	31	3	0.62	<0.10	<0.24	Jul 65	19.9	<4.0
Tenn:	Nashville	30	7	0.49	<0.10	<0.17	Oct 65	66.5	<13.2
Tex:	Austin	28	1	0.24	<0.10	<0.14	May 65	8.8	<1.8
	El Paso	29	5	0.22	<0.10	<0.13	Nov 65	7.6	<1.8
Utah:	Salt Lake City	28	7	0.54	<0.10	<0.24	Feb 65	28.9	<5.9
Vt:	Barre	31	12	0.85	<0.10	0.34	Jun 65	73.1	<14.6
Va:	Richmond	31	9	0.66	<0.10	<0.20	Jun 65	194.7	<38.9
Wash:	Seattle	31	4	0.30	<0.10	<0.12	May 65	10.0	<2.0
	Spokane	30	2	0.54	<0.10	0.25	Apr 65	13.2	<2.6
W. Va:	Charleston	31	10	0.51	<0.10	<0.19	Oct 65	77.1	<15.4
Wis:	Madison	30	4	0.54	0.12	0.23	Jun 65	67.8	<13.5
Wyo:	Cheyenne	30	5	0.43	<0.10	<0.10	Jun 65	21.3	<6.0
Network summary [c]		1,046	332	1.08	<0.10	<0.20		67.2	<13.9

Key to symbols: Blank—no report received. NS—no sample collected.

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.

[b] If any individual precipitation samples have activity concentrations under 200 pCi/liter, a less-than sign is placed before the total deposition value.

[c] For the network summary, all averages are arithmetic means of station averages.

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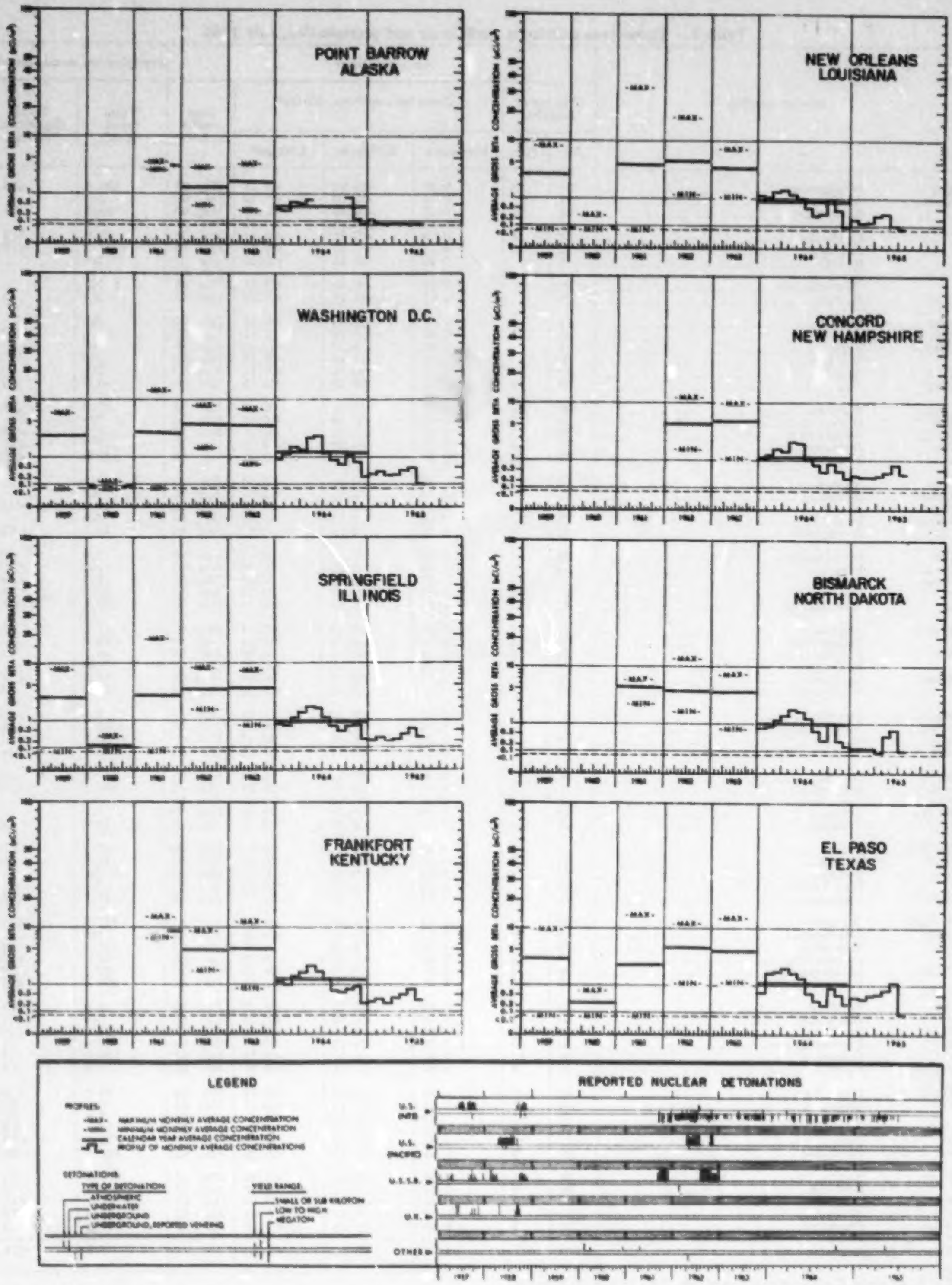

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959—July 1965

2. Canadian Air and Precipitation Monitoring Program, July 1965 [2]

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*5–10*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa for analysis.

To determine the beta activity a 2-inch diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a strontium-90—yttrium-90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for July 1965 are given in table 2.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter together with the polyethylene liner is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin-end-window Geiger-

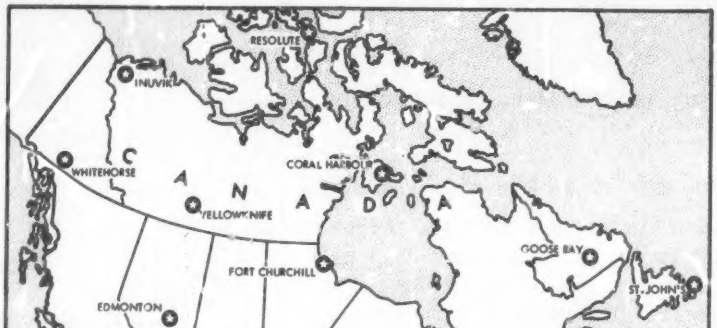

Figure 3. Canadian air and precipitation sampling stations

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[2] Prepared from information and data in the August 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Mueller counter calibrated with a strontium-90—yttrium-90 source. Gross beta activities in precipitation for July 1965 are given in table 2.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. The July 1965 gross beta deposition values are given in table 2. Results of radionuclide analyses of deposition are given in table 3. A review and discussion of fallout levels in Canada during 1964 have been presented by Booth *et al.* (*10*).

Table 2. Canadian gross beta activity in surface air and precipitation, July 1965

Station	Air surveillance				Precipitation measurements	
	Number of samples	Beta activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.8	0.1	0.4	111	13.1
Coral Harbour	31	0.4	0.0	0.2	153	6.2
Edmonton	31	0.6	0.1	0.3	107	5.8
Ft. Churchill	31	0.6	0.0	0.2	114	4.7
Ft. William	31	0.8	0.0	0.3	124	5.2
Fredericton	31	0.8	0.1	0.3	117	5.3
Goose Bay	31	0.6	0.0	0.3	82	9.6
Halifax	31	0.7	0.0	0.3	78	4.3
Inuvik	31	1.0	0.0	0.3	96	4.4
Montreal	31	1.1	0.1	0.4	105	9.0
Moosonee	31	0.6	0.0	0.2	110	9.3
Ottawa	30	0.9	0.0	0.3	112	7.0
Quebec	30	1.1	0.0	0.3	135	14.6
Regina	31	0.6	0.2	0.3	175	7.5
Resolute	31	0.1	0.0	0.1	NS	NS
St. John's, Nfld	25	0.7	0.0	0.3	63	3.9
Saskatoon	31	0.4	0.1	0.2	448	13.9
Sault Ste. Marie	31	0.6	0.0	0.3	99	9.9
Toronto	31	0.8	0.0	0.4	106	10.3
Vancouver	31	0.3	0.0	0.1	278	1.6
Whitehorse	31	0.6	0.0	0.2	276	3.0
Windsor	31	1.0	0.1	0.3	79	5.5
Winnipeg	31	0.6	0.0	0.2	78	6.2
Yellowknife	2	0.2	0.2	0.2	158	5.8
Average		0.7	0.0	0.3	139	7.2

NS—no sample.

Table 3. Radionuclide deposition (nCi/m²) in Canadian fallout, July 1965[a]

Station	^{89}Sr	^{90}Sr	^{137}Cs	^{95}Zr	^{140}Ba
Calgary	0.70	1.17	1.69	0.16	0.28
Coral Harbour	0.26	0.28	0.44	NA	NA
Edmonton	0.00	0.78	1.14	NA	NA
Ft. Churchill	0.32	0.36	0.56	NA	NA
Ft. William	0.21	0.37	0.62	NA	NA
Fredericton	0.25	0.46	0.72	NA	NA
Goose Bay	0.55	0.92	1.17	NA	NA
Halifax	0.20	0.34	0.36	0.02	0.13
Inuvik	0.27	0.44	0.52	NA	NA
Montreal	0.59	0.74	1.06	0.21	0.46
Moosonee	0.73	0.68	1.00	NA	NA
Ottawa	0.28	0.68	0.99	NA	NA
Quebec	1.05	1.35	1.98	NA	NA
Regina	0.33	0.61	0.88	NA	NA
Resolute	NS	NS	NS	NS	NS
St. John's, Nfld	0.52	0.44	0.65	NA	NA
Saskatoon	0.38	0.76	1.56	NA	NA
Sault Ste. Marie	0.65	0.78	1.05	NA	NA
Toronto	0.56	0.81	0.91	NA	NA
Vancouver	0.00	0.04	0.11	0.02	0.07
Whitehorse	0.12	0.27	0.46	NA	NA
Windsor	0.28	0.36	0.60	NA	NA
Winnipeg	0.36	0.53	0.75	0.10	0.09
Yellowknife	0.33	0.53	0.63	NA	NA
Average	0.39	0.60	0.86	0.10	0.21

Key to symbols:
NA—no analysis.
NS—no sample.

[a] Samples from all stations are routinely analyzed for ^{89}Sr, ^{90}Sr, and ^{137}Cs; samples from five selected stations are regularly analyzed for ^{95}Zr and ^{140}Ba. Negligible quantities are not reported.

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3. Mexican Air Monitoring Program July 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Commision Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*11–15*).

In 1961, the CNEN appointed its Division of Radiological Protection (DRP) to establish a new radiation surveillance network. This network consists of 17 stations (see figure 4), 12 of

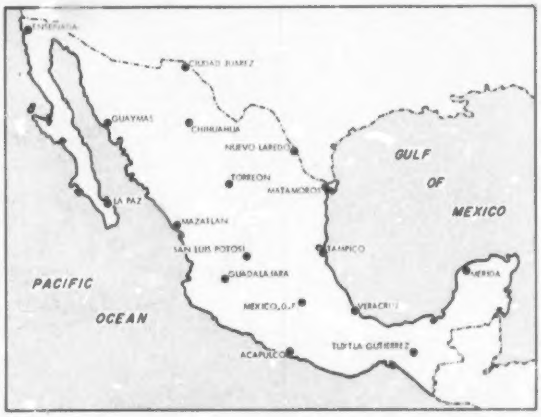

Figure 4. Fallout network sampling stations in Mexico

which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Enseñada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 to 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- x 8-inch glass fiber filter, using high-volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radiactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 to 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated back to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during July 1965 are presented in table 4.

Table 4. Gross beta activity of airborne particulates, Mexico, July 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	16	<0.1	<0.1	<0.1
Ciudad Juáres	15	0.2	<0.1	0.1
Chihuahua	20	0.3	<0.1	0.1
Enseñada	3	0.1	0.1	0.1
Guadalajara	13	<0.1	<0.1	<0.1
Guaymas	6	<0.1	<0.1	<0.1
La Paz	16	0.9	<0.1	0.2
Matamoros	5	0.2	<0.1	0.1
Mazatlán	16	0.3	<0.1	0.1
Mérida	22	0.1	<0.1	<0.1
México, D.F.	8	0.1	<0.1	<0.1
Nuevo Laredo	8	0.3	<0.1	0.1
San Luis Potosí	15	0.1	<0.1	<0.1
Tampico	17	0.1	<0.1	<0.1
Torréon	28	0.4	<0.1	0.1
Tuxtla Gutiérrez [a]	NS	NS	NS	NS
Veracruz	14	0.2	<0.1	<0.1

NS, no sample collected.

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4. Pan American Air Sampling Program July 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by six countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The six air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; in Trinidad, West Indies, by the University of the West Indies; and in Buenos Aires, Argentina, by the Ministry of Social Welfare and Public Health.

The May 1965 air monitoring results from the six participating countries are given in table 5.

Table 5. Gross beta activity in surface air (concentrations in pCi/m³), July 1965

Sampling stations	Number of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	14	0.22	<0.10	<0.12
Caracas, Venezuela	17	0.15	<0.10	<0.10
Lima, Peru	24	0.10	<0.10	<0.10
Santiago, Chile	16	0.19	<0.10	<0.12
Trinidad, West Indies	14	0.19	<0.10	<0.11
Buenos Aires, Argentina	NS	NS	NS	NS

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

NS, no samples analyzed by laboratory.

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RADIOCARBON IN SURFACE AIR

J. C. Drobinski, Jr[1]

Prior to 1950, the natural radioactive carbon dioxide content of the troposphere and lower stratosphere was in a steady-state equilibrium (*1*); that is, conditions were such that the cosmic ray production of carbon–14 by the (n, p) reaction on nitrogen in the upper atmosphere equalled its radioactive decay. Under these conditions, the natural level of carbon–14 in the atmosphere and biosphere was about 14 ± 1 disintegrations per minute per gram of carbon. Recently, it has been broadly established that this equilibrium has existed, probably with minor fluctuations, for at least the last 300,000 years (*2*).

The detonation of fusion and high-yield fission devices, which began in 1952, has added macro amounts of carbon–14 to the natural reservoir. It appears that most of this activity was injected into the stratosphere followed by only a gradual entrance into the troposphere. As a result, the rise in tropospheric levels of carbon–14 has been slow. Data on carbon–14 concentrations in the stratosphere have been reported by Hagemann (*3*). Table 1 shows increases in the carbon–14 levels reported for 1956–1962 in the northern troposphere (*4*).

Table 1. Tropospheric inventory of artificial carbon-14

Year	Increase, percent[a]
1956	8
1957	12
1958	18
1959	21
1960	21
1961	24
1962	28

[a] Over 1950 level.

Although the dose rate from radioactive carbon–14 is very low, its long half-life (5,740 years) (*5*) and its ultimate entry into the biosphere make it probably the most significant radionuclide of genetic importance produced by nuclear detonations (*6,7*). Since very little carbon is absorbed through respiration, its principal route of entry into man is through the food chain. Carbon–14, as carbon dioxide, is incorporated into plant tissue through photosynthesis; it then enters the human food chain either directly or through animal intermediates. Because the carbon–14 content in animals tends to lag behind surface air levels (*8–11*), data on the concentrations of carbon–14 in surface air can serve as an early indicator of possible changes in the ecological system leading to man.

Sample collection

Carbon dioxide is collected at Northeastern Radiological Health Laboratory approximately every two weeks. The intake is located about 20 feet above ground level. A dehumidifier-compressor,[2] passes air through silica gel to remove moisture. The air then passes through a trap cooled with dry ice-ethanol (–78° C.) to remove any remaining traces of water vapor and then to a bed of Linde molecular sieve (type 5A) which absorbs the carbon dioxide, while permitting the oxygen, nitrogen, and inert gases to pass through. Prior removal of moisture is necessary since the molecular sieve also absorbs water. Although molecular sieves can be operated at high flow rates with good efficiency and low-pressure drop, the particular dehumidifier-compressor unit available has a maximum operating capacity of 40 cubic feet of air per hour. Therefore the dehumidifying-absorption process is continued for 24–26 hours to obtain sufficient sample (about 8 liters of carbon dioxide,[3] corresponding to 4.3 grams of carbon). Collection of the sample over such a long period also minimizes the effect of transient meterological conditions.

After the carbon dioxide has been absorbed by the molecular sieve at room temperature, it is transferred to a collection system. The carbon dioxide is desorbed from the sieve material at 500° C. and is collected in a trap cooled by liquid nitrogen (–196° C.) after passage through a trap cooled by dry ice-ethanol (–78° C.). Volatile impurities (air) are removed by pumping to a pressure of 15 microns while the carbon dioxide is frozen in the liquid nitrogen trap. Finally, the gas is sublimed into storage tanks where the quantity collected is measured. Observed yields have been 95 percent or more.

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[1] Mr. Drobinski is Chief, Carbon–Tritium Section, Northeastern Radiological Health Laboratory, Division of Radiological Health, 109 Holton Street, Winchester, Massachusetts 01890.

[2] Communication Products Company, Marlboro, New Jersey.

[3] At standard conditions of temperature and pressure.

Purification and counting

The carbon dioxide is then transferred to a purification system where it is purified by a series of vacuum evaporation-condensation steps through activated coconut charcoal. The final "evaporation" is carried out at −78° C. so that any radon present will be retained on the charcoal. In this "evaporation," the CO_2 also passes through phosphorus pentoxide (P_2O_5) before transfer to the counters.

The carbon–14 content is measured in gas-phase carbon dioxide proportional counters. The counting chamber volume is 7.5 liters, at an operating pressure of 30 cm. mercury. Background is reduced by an iron shield 12-inches thick and by an annular anti-coincidence shield surrounding the counter. The system has been described by Drobinski (*11*). Background is about 20 counts per minute and the standard deviation of the net activity is about 1 cpm for a 180-minute counting period.

Results and interpretation

Table 2 lists the carbon–14 activities observed in the atmosphere from January 1964 to April 1965. The actual activity (disintegrations per minute of carbon–14 per gram of carbon) and the percentage increase over 1950 levels (△carbon–14) are presented. The latter factor is calculated as follows:

$$\Delta\text{carbon-14} = \frac{(\text{dpm/g}) - 14}{14} \times 100$$

where 14 is the 1950 activity in dpm/g of carbon.

The data in the table show an increase in the carbon–14 content over the period of study, suggesting the entrance of this nuclide into the troposphere from the stratospheric inventory. Most of the increase was noted in March 1964. Subsequent to this date, the level remained fairly constant. Fluctuations in carbon–14 concentrations from sample to sample which are greater than analytical error may be due to meteorological conditions. The low values of some samples may be due to dilution with inactive carbon dioxide resulting from the combustion of fossil fuels (Suess effect) (*12*). Although some geographical variability of carbon–14 may be expected, the data obtained at Winchester agree in general with those reported elsewhere (*10, 13*).

Table 2. Carbon-14 content in surface air, Winchester, Massachusetts

Date of sampling	dpm/g C	Percent $\Delta^{14}C$ [a]	Date of sampling	dpm/g C	Percent $\Delta^{14}C$ [a]
1964			Sept 15	22.6±1.0	61
			Oct 15	22.5±1.0	60
Feb 5	17.0±1.2	21	Nov 16	23.7±1.0	69
Feb 10	19.2±1.1	37	Dec 1	24.8±1.0	77
Mar 3	22.0±0.9	57	Dec 15	23.9±1.5	70
Mar 17	21.9±0.8	57			
Mar 31	23.3±1.1	66	1965		
April 15	23.4±0.8	67			
April 28	20.1±1.0	43	Jan 5	21.2±1.1	52
May 14	21.8±0.9	56	Feb 2	19.0±1.0	36
June 3	22.6±1.0	61	Feb 17	22.1±1.0	58
June 23	21.9±1.0	56	Mar 2	21.3±1.0	52
July 15	22.9±1.0	63	Mar 16	24.2±1.1	73
Aug 3	23.3±1.0	67	Mar 31	21.0±1.0	50
Aug 14	22.3±1.0	59	April 13	21.7±1.0	55

[a] Percent above natural level of 14±1 dpm/g carbon in 1950.

Acknowledgment

The author wishes to express his appreciation to Dr. B. Shleien who cooperated in the construction of the sampling equipment, and to Messrs. D. La Gatta, C. Beatrice, and R. Parent of the Carbon–Tritium Staff at the Northeastern Radiological Health Laboratory.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, July 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Samples are collected through the cooperation of State and local milk sanitation authorities. According to established procedures, the sample at each station is composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from 1 day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL) or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry.[1] After the weekly samples are gamma-scanned, samples from 2 consecutive weeks are composited and analyzed

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

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radiochemically to determine strontium–89 and strontium–90. With all such measurements there is an inherent statistical variation. For the low radionuclide levels usually observed in milk and other environmental samples, this variation on a percentage basis is relatively high. It depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

Table 1. Analytical errors associated with determinations of radionuclides concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	less than 100	10	100 or greater	10
Barium-140	less than 100	10	100 or greater	10
Cesium-137	less than 100	10	100 or greater	10
Strontium-89	less than 50	5	50 or greater	10
Strontium-90	less than 20	2	20 or greater	10

[a] Two standard deviations

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, 10; barium–140, 10; and iodine–131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations determined from the gamma spectrum, but are not reported herein.

Data presentation

Table 2 presents summaries of the analyses for July 1965. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. A modified averaging procedure has been used for iodine–131 and barium–140 since October 1963, when nondetectable concentrations of these radionuclides began to be considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations.

The distribution of monthly average strontium–90 concentrations as observed in pasteurized milk for the months February through July 1965 is presented in table 3. The maximum monthly average concentration of strontium–90 for July was 37 pCi/liter, observed at Minot, North Dakota. This level is in Range II as defined by the Federal Radiation Council (20–200 pCi/liter). The overall PMN average monthly strontium–90 concentration in pasteurized milk for July was 17.2 pCi/liter as compared to 20.0 pCi/liter in June 1965. The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

The network average cesium–137 concentration in milk for July 1965 was 51 pCi/liter as compared to 61 pCi/liter in June 1965. The maximum monthly average cesium–137 concentration in pasteurized milk was 185 pCi/liter, observed at Tampa, Florida. The distribution of monthly average cesium–137 concentrations in milk for the months February through July 1965 is presented in table 4.

The decrease in radionuclide concentrations in milk observed during February through July 1965 can be expected to continue in the absence of atmospheric nuclear testing.

During July 1965, four stations exhibited an iodine–131 monthly average of 10 pCi/liter. The presence of iodine–131 and strontium–89 in pasteurized milk during July 1965 is presumed a consequence of the mainland China atmospheric nuclear test of May 14, 1965.

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk, second quarter 1965 and July 1965[a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		Second quarter	Average for July	Second quarter	Average for July	Second quarter	Average for July	Second quarter	Average for July	Second quarter	Average for July
Ala:	Montgomery	1.17	1.12	<5	<5	18	13	55	40	0	0
Alaska:	Palmer	1.22	1.23	<5	<5	20	13	65	50	0	0
Ariz:	Phoenix	1.21	1.21	<5	<5	5	5	20	20	0	0
Ark:	Little Rock	1.15	1.13	5	15	38	31	70	60	10	0
Calif:	Sacramento	1.25	1.31	<5	<5	8	6	35	30	0	0
	San Francisco	1.26	1.27	<5	<5	11	7	35	30	0	0
C.Z:	Cristobal	1.10	1.11	<5	<5	4	4	35	30	0	0
Colo:	Denver	1.33	1.26	<5	10	19	15	70	45	0	0
Conn:	Hartford	1.11	1.09	<5	<5	15	15	75	60	0	0
Del:	Wilmington	1.14	1.12	<5	5	19	16	70	50	0	0
D. C:	Washington	1.15	1.12	5	<5	17	14	55	40	10	0
Fla:	Tampa	1.16	1.16	<5	<5	12	11	175	185	0	0
Ga:	Atlanta	1.15	1.14	<5	<5	29	21	85	60	0	0
Hawaii:	Honolulu	1.23	1.16	<5	<5	10	7	55	40	0	0
Idaho:	Idaho Falls	1.27	1.26	<5	<5	20	23	95	60	10	10
Ill:	Chicago	1.13	1.11	<5	<5	17	11	75	40	10	0
Ind:	Indianapolis	1.15	1.12	5	<5	19	14	55	30	10	0
Iowa:	Des Moines	1.26	1.18	10	5	23	20	55	35	20	0
Kans:	Wichita	1.25	1.20	<5	5	18	19	50	35	10	0
Ky:	Louisville	1.15	1.12	5	10	24	20	45	30	10	0
La:	New Orleans	1.20	1.16	5	5	42	34	80	60	10	0
Maine:	Portland	1.12	1.11	<5	10	21	23	125	110	0	0
Md:	Baltimore	1.14	1.10	5	<5	19	17	60	50	10	0
Mass:	Boston	1.13	1.11	<5	10	22	22	125	100	0	0
Mich:	Detroit	1.13	1.11	<5	<5	17	11	75	40	10	0
	Grand Rapids	1.16	1.14	<5	5	19	16	80	55	10	0
Minn:	Minneapolis	1.29	1.31	10	10	28	26	90	65	20	
Miss:	Jackson	1.18	1.18	5	<5	34	29	55	45	0	0
Mo:	Kansas City	1.25	1.22	10	10	22	19	45	30	30	0
	St. Louis	1.20	1.19	5	10	19	16	45	25	20	0
Mont:	Helena	1.28	1.23	<5	10	20	19	95	65	10	0
Nebr:	Omaha	1.19	1.21	5	<5	21	17	50	35	20	0
Nev:	Las Vegas	1.28	1.18	<5	<5	7	8	40	20	10	0
N. H:	Manchester	1.15	1.13	<5	5	25	25	150	130	0	0
N. J:	Trenton	1.11	1.09	<5	5	16	16	70	45	0	0
N. Mex:	Albuquerque	1.23	1.23	<5	<5	11	8	35	20	0	0
N. Y:	Buffalo	1.10	1.11	<5	5	17	12	95	55	0	0
	New York	1.11	1.09	<5	5	21	20	90	65	0	0
	Syracuse	1.10	1.11	<5	10	18	12	80	45	0	0
N. C:	Charlotte	1.20	1.12	5	<5	27	25	65	50	0	0
N. Dak:	Minot	1.25	1.27	10	20	57	37	120	70	10	0
Ohio:	Cincinnati	1.13	1.12	<5	5	18	14	50	30	10	0
	Cleveland	1.13	1.11	5	10	20	13	75	40	10	0
Okla:	Oklahoma City	1.12	1.08	5	5	20	16	45	30	10	0
Ore:	Portland	1.30	1.30	<5	<5	24	17	90	50	0	0
Pa:	Philadelphia	1.13	1.05	<5	<5	19	15	65	40	0	0
	Pittsburgh	1.14	1.12	5	10	25	22	95	65	10	0
P. R:	San Juan	1.12	1.11	<5	<5	11	10	50	45	0	0
R. I:	Providence	1.12	1.12	<5	<5	20	19	95	85	0	0
S. C:	Charleston	1.16	1.13	<5	<5	27	23	100	70	0	0
S. Dak:	Rapid City	1.05	1.04	10	20	33	28	105	55	10	10
Tenn:	Chattanooga	1.19	1.14	5	5	30	26	65	45	0	0
	Memphis	1.15	1.13	5	10	26	21	45	30	10	0
Tex:	Austin	1.12	1.12	<5	<5	8	6	25	25	0	10
	Dallas	1.17	1.11	5	<5	20	14	45	30	0	0
Utah:	Salt Lake City	1.39	1.34	<5	<5	26	15	120	80	10	0
Vt:	Burlington	1.12	1.11	<5	5	21	21	100	75	0	0
Va:	Norfolk	1.17	1.14	5	<5	21	18	60	45	10	10
Wash:	Seattle	1.27	1.26	<5	<5	25	19	105	80	0	0
	Spokane	1.30	1.30	<5	<5	27	23	90	60	0	0
W. Va:	Charleston	1.13	1.10	10	5	20	19	40	30	10	0
Wis:	Milwaukee	1.19	1.19	<5	5	17	11	85	45	10	0
Wyo:	Laramie	1.23	1.31	5	<5	17	17	70	55	10	0
Network average		1.18	1.16	<5	5	20.7	17.2	72	51	6	1

[a] Results of all barium-lanthanum-140 analyses were zero.

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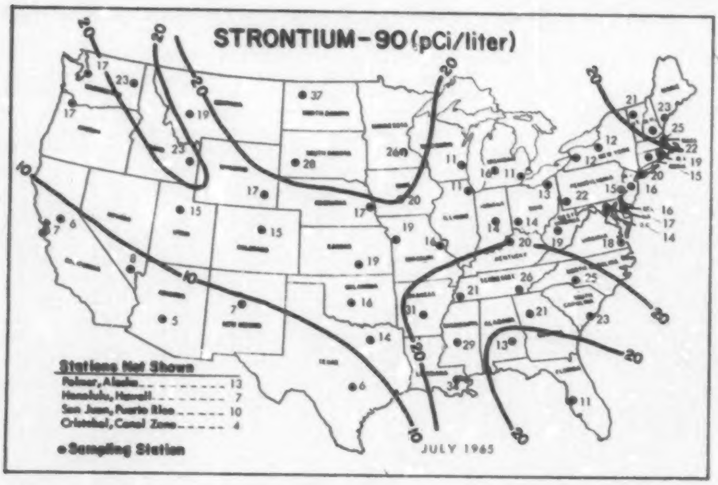
STRONTIUM-90 (pCi/liter)
Stations Not Shown
Palmer, Alaska 13
Honolulu, Hawaii 7
San Juan, Puerto Rico 10
Cristobal, Canal Zone 4
• Sampling Station
JULY 1965

Figure 1. Strontium-90 concentrations in pasteurized milk, July 1965

Table 3. Frequency distribution, strontium-90 concentrations in milk at PMN stations, July 1964 and February–July 1965

Strontium-90 (pCi/liter)	Number of stations						
	1964	1965					
	July	Feb	Mar	Apr	May	June	July
Under 10	6	3	5	5	4	7	8
10–19	6	31	29	23	26	21	34
20–29	29	22	21	27	25	29	18
30–39	14	5	6	5	5	4	3
40–49	4	2	1	2	2	2	0
50–59	1	0	1	0	0	0	0
60–69	2	0	0	1	1	0	0
70–79	0	0	0	0	0	0	0

Table 4. Frequency distribution, cesium-137 concentrations in milk at PMN stations, July 1964 and February–July 1965

Cesium-137 (pCi/liter)	Number of stations						
	1964	1965					
	July	Feb	Mar	Apr	May	June	July
Under 50	4	8	9	7	17	19	34
50–99	24	38	36	35	31	38	25
100–149	21	15	16	18	13	5	3
150–199	8	2	2	3	2	1	1
200–249	3	0	0	0	0	0	0
250–299	2	0	0	0	0	0	0

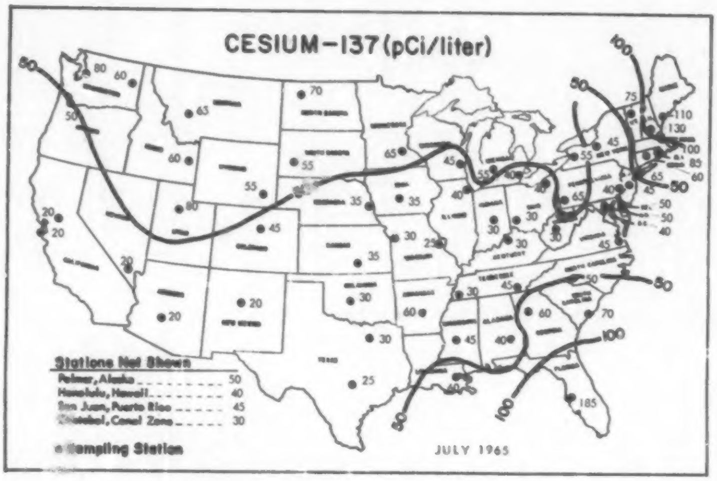
CESIUM-137 (pCi/liter)
Stations Not Shown
Palmer, Alaska 50
Honolulu, Hawaii 40
San Juan, Puerto Rico 45
Cristobal, Canal Zone 30
• Sampling Station
JULY 1965

Figure 2. Cesium-137 concentrations in pasteurized milk, July 1965

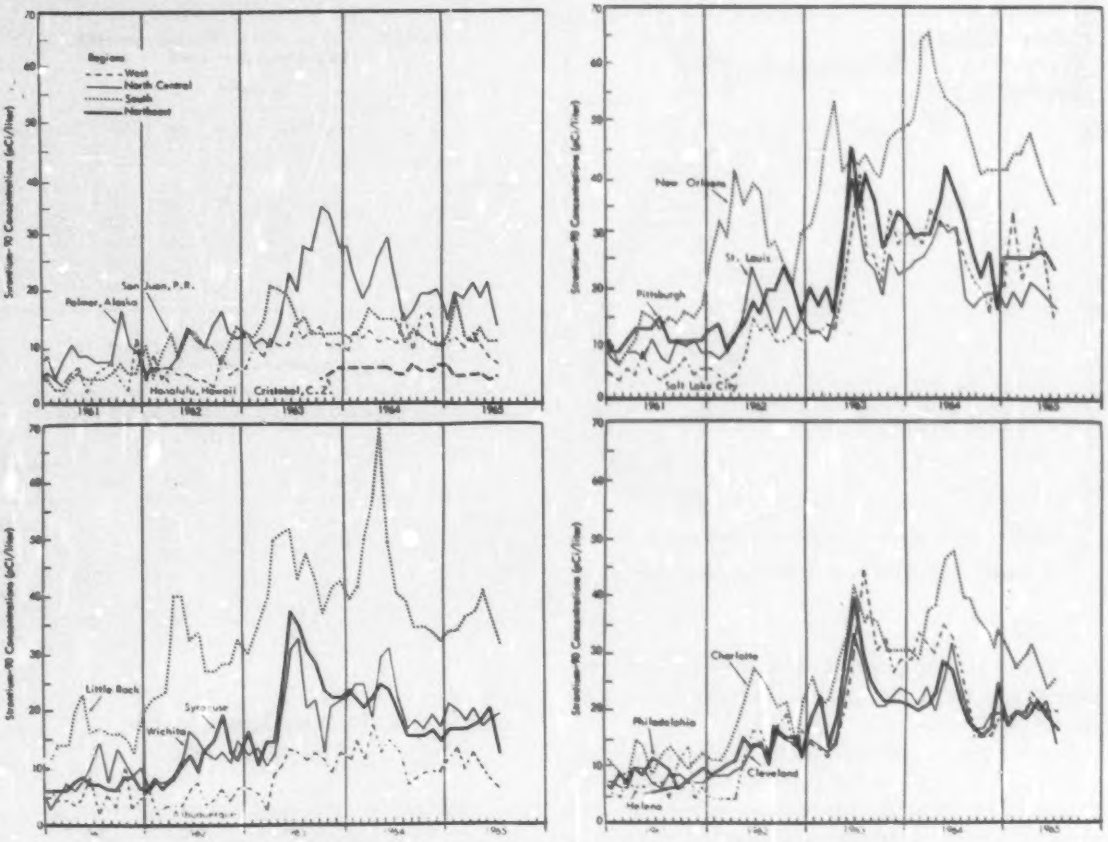

Figure 3. Strontium-90 concentrations in pasteurized milk, 1961—July 1965

2. Florida Milk Network
July–December 1964 and Annual Summary

Division of Radiological and Occupational Health, Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine-131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium-89, strontium-90, and cesium-137, in addition to iodine-131. Raw milk samples are received from the six areas shown in figure 4. Samples for iodine-131 analysis are taken from a tank truck, the route of which passes by farms widely dispersed over the area represented. Where there is no route representative of a large portion of an area, samples collected from selected farms are combined. When iodine-131 is detectable in milk, samples are collected weekly. In the interest of maintaining an active standby capability, samples are now collected and analyzed for this nuclide on a monthly basis. A regional State Board of Health Laboratory is located in each of the six areas referred to in this report. Each laboratory prepares a monthly composite sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the West Florida region, where locally-grown feeds are used, to larger farms in the Southern areas, where different types of grass and predominantly purchased feeds are used.

Analytical procedures

Cesium-137 is determined by gamma scanning 1 liter of milk in a Marinelli beaker with a 4- x 4-inch sodium iodide crystal and

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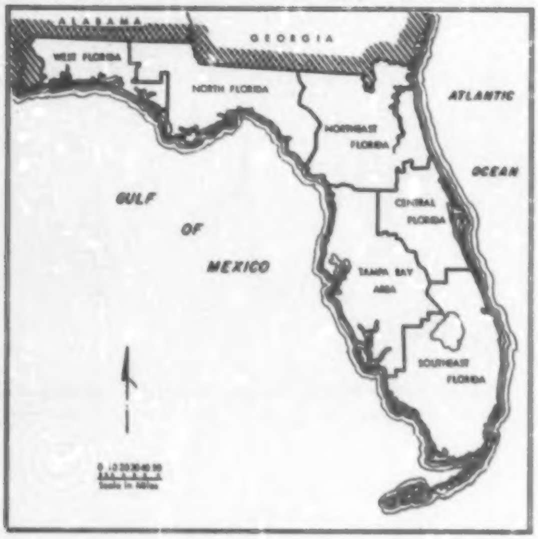

Figure 4. Florida milk sampling locations

multichannel analyzer. The sample is then prepared for radiostrontium analysis by evaporating and ashing.

Strontium is precipitated as a carbonate, counted for total radiostrontium activity, and stored for yttrium ingrowth. After the ingrowth period, yttrium is separated with carrier as an oxalate and counted in a low-background beta counter to determine strontium-90. Strontium-89 is then calculated as the difference between total radiostrontium and strontium-90 (as yttrium).

Results and discussion

During the period July to December 1964, strontium-89 and iodine-131 concentrations remained below the detectable level of 5 pCi/liter. Strontium-90 analyses were not performed routinely during the last half of 1964.

Table 5 presents the monthly average cesium-137 concentrations in Florida raw milk from July through December 1964.

A summary of 1964 observed cesium-137 concentrations is presented in table 6 as quarterly and yearly averages for each area and for the State. Following the mainland China nuclear test of October 16, 1964, raw milk samples were collected every other day at Pensacola from October 23 to November 12, 1964.

Table 5. Cesium-137 in Florida raw milk July–December 1964

(pCi/liter)

Area	July	Aug	Sept	Oct	Nov	Dec	Average
West Fla.	169	174	145	169	106	77	140
North Fla.	214	162	156	146	134	91	150
Northeast Fla.	335	322	240	209	199	120	238
Central Fla.	346	342	229	356	347	188	303
Tampa Bay	283	238	273	266	198	168	238
Southeast Fla.	284	296	266	231	211	179	244
Average	272	256	218	231	199	137	219

Table 6. Quarterly summary of cesium-137 concentrations in raw milk, 1964

(pCi/liter)

Area	Quarter				Annual average
	First	Second	Third	Fourth	
West Fla.	205	260	163	117	186
North Fla.	183	267	177	124	188
Northeast Fla.	179	249	299	176	226
Central Fla.	255	335	306	300	299
Tampa Bay	203	257	265	211	234
Southeast Fla.	212	254	278	207	238
Average	206	270	248	189	228

3. Indiana Milk Network April–June 1965

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. To analyze radionuclide concentrations in Indiana milk effectively, the State was geographically divided into five major milksheds; northeast, northwest, central, southeast, and southwest (figure 5). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are routinely analyzed for strontium-89, strontium-90, cesium-137, iodine-131, and barium-140. Initially, cesium-137, iodine-131, and barium-140 were analyzed weekly. When iodine-131 concentrations exceeded 100 pCi/liter, the sampling frequency was increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was reduced to once a month for the northeast, southeast, and southwest milksheds. Monthly analyses for strontium-89 and strontium-90 are performed for each station.

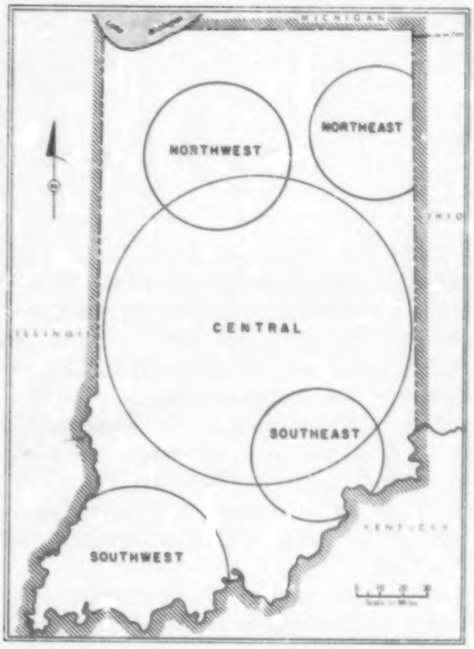

Figure 5. Indiana milk sampling locations

Analytical procedures

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion exchange separation (*2, 3*) and subsequent low-background beta counting. The limits of detectability for strontium–89 and strontium–90 are 5 and 1 pCi/liter, respectively. Cesium–137, iodine–131, and barium–140 are determined by gamma scintillation spectrometry. The counting system consists of a 512–channel pulse-height analyzer and a shielded 4- x 4-inch sodium iodide crystal detector. The limit of detectability for barium–140 and iodine–131 is 5 pCi/liter. Cesium–137 concentrations are subject to a 6 percent error at 100 pCi/liter.

Results and discussion

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 7 for April through June 1965.

The monthly network average concentrations of strontium–89, strontium–90, and cesium–137 are presented graphically in figure 6. Strontium–89 concentrations increased in the spring of 1962 following atmospheric nuclear testing. Subsequently, these levels decreased until by the end of 1963 they were below detectable levels. Strontium–90 and cesium–137 concentrations also increased following 1962 atmospheric nuclear testing to a peak in the summer of 1963. With the subsequent cessation of atmospheric nuclear testing, these levels began a downward trend.

Monthly average concentrations in strontium–89, iodine–131, and barium–140 increased above detectable levels in May and June 1965. This increase is presumed to have resulted from the second mainland China test of May 14, 1965, and can be expected to decrease subsequently.

During the period covered, concentrations did not reach levels requiring countermeasures based upon health implications. Criteria for such remedial action have been outlined by the Federal Radiation Council (*4*).

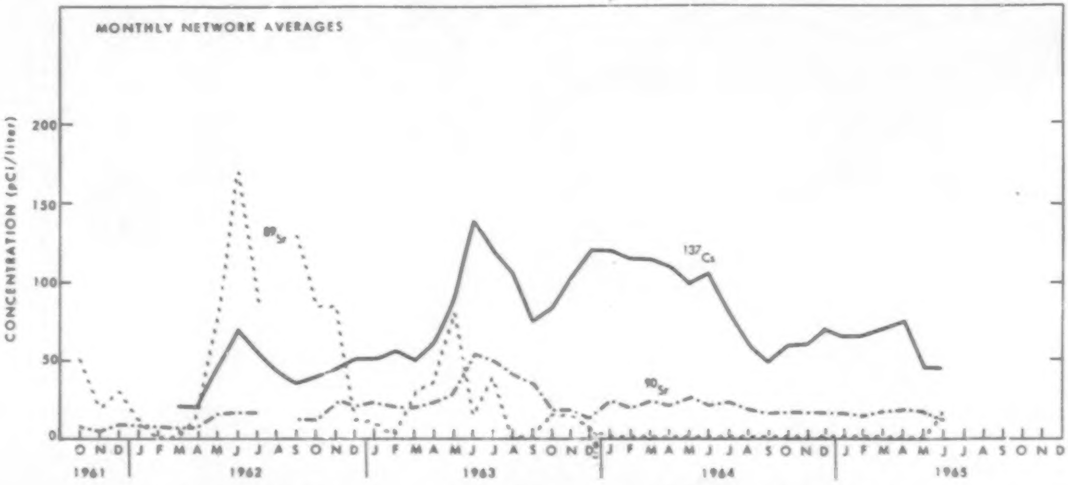

Figure 6. Radionuclide concentrations in Indiana Pasteurized Milk Network, 1961—June 1965

Table 7. Radionuclide concentrations in Indiana milk, April–June 1965

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-89 (pCi/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun
Northeast	1.05	1.08	1.13	1,230	1,410	1,340	0	0	10	14	13	11	0	80	20	85	40	45	0	20	0
Southeast	NS	1.12	1.17	NS	1,200	1,350	NS	0	10	NS	16	11	NS	0	0	NS	45	35	NS	0	0
Central	1.11	1.10	1.13	1,310	1,330	1,380	0	0	20	14	13	11	0	10	30	65	45	50	0	0	10
Southwest	1.12	1.12	1.15	1,300	1,340	1,350	0	0	15	18	15	14	0	0	0	45	40	35	0	0	0
Northwest	1.11	1.08	1.13	1,330	1,330	1,420	0	0	20	14	15	10	0	20	40	80	55	55	0	10	10
Average	1.10	1.10	1.14	1,290	1,320	1,370	0	0	15	15	14	11	0	20	20	70	45	45	0	10	0

NS, no sample taken.

4. Michigan Milk Network January–June 1965

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 7). Daily samples within each area are composited in proportion to sales volume.

Analytical procedures

The resultant samples are analyzed weekly for strontium–90, iodine–131, cesium–137, potassium–40, and barium-lanthanum–140. The analytical procedure for strontium–90 is based upon ion exchange methods. Cations are eluted from the ion exchange resin with a sodium chloride solution. Subsequently, calcium and strontium are separated using a nitric acid method. The strontium is scavenged from the rare earths and set aside for a 2-week yttrium–90 ingrowth. The yttrium–90 is then separated and counted in a low-background beta counter after which the strontium–90 is calculated.

Iodine–131, cesium–137, potassium–40, and barium-lanthanum–140 concentrations are

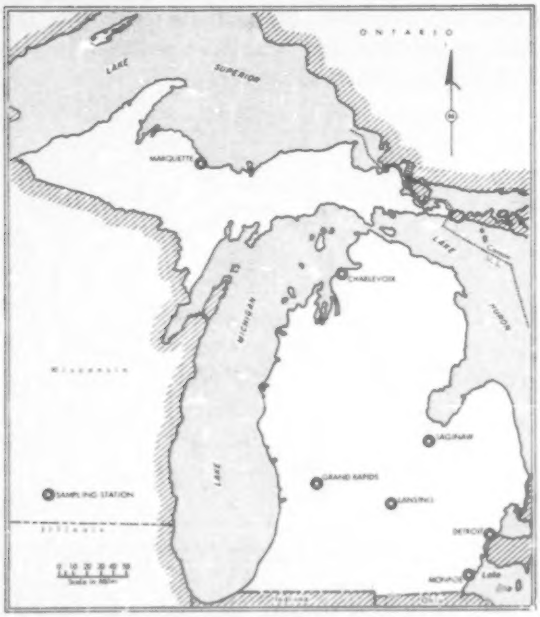

Figure 7. Michigan milk sampling stations

Table 8. Radionuclides in seven Michigan milk producing areas, January–June 1965 [a]

(pCi/liter)

Station and month	Potassium-40	Strontium-90	Iodine-131	Cesium-137
Charlevoix:				
January	1,310	25	<14	95
February	1,370	30	<14	94
March	1,330	28	<14	95
April	1,330	25	<14	87
May	1,380	26	<14	87
June	1,310	21	19	61
Detroit:				
January	1,350	18	<14	69
February	1,370	19	<14	70
March	1,320	21	<14	69
April	1,310	16	<14	69
May	1,330	18	<14	61
June	1,300	17	21	38
Grand Rapids:				
January	1,370	20	<14	71
February	1,380	21	<14	72
March	1,330	21	<14	78
April	1,330	19	<14	74
May	1,360	21	<14	71
June	1,290	20	18	53
Lansing:				
January	1,450	18	<14	60
February	1,340	18	<14	65
March	1,360	20	<14	74
April	1,350	18	<14	70
May	1,330	19	<14	58
June	1,340	17	21	43
Marquette:				
January	1,380	NA	<14	144
February	1,360	42	<14	145
March	1,350	44	<14	148
April	1,360	34	<14	152
May	1,430	38	<14	140
June	1,350	36	<14	106
Monroe:				
January	1,320	12	<14	48
February	1,320	14	<14	54
March	1,300	14	<14	55
April	1,320	12	<14	53
May	1,350	14	<14	50
June	1,340	16	18	37
Saginaw:				
January	1,350	16	<14	66
February	1,360	16	<14	67
March	1,360	19	<14	65
April	1,330	14	<14	69
May	1,330	17	<14	67
June	1,320	14	<14	48

NA, no analyses performed

[a] Barium-lanthanum-140 values all less than 4 pCi/liter.

95

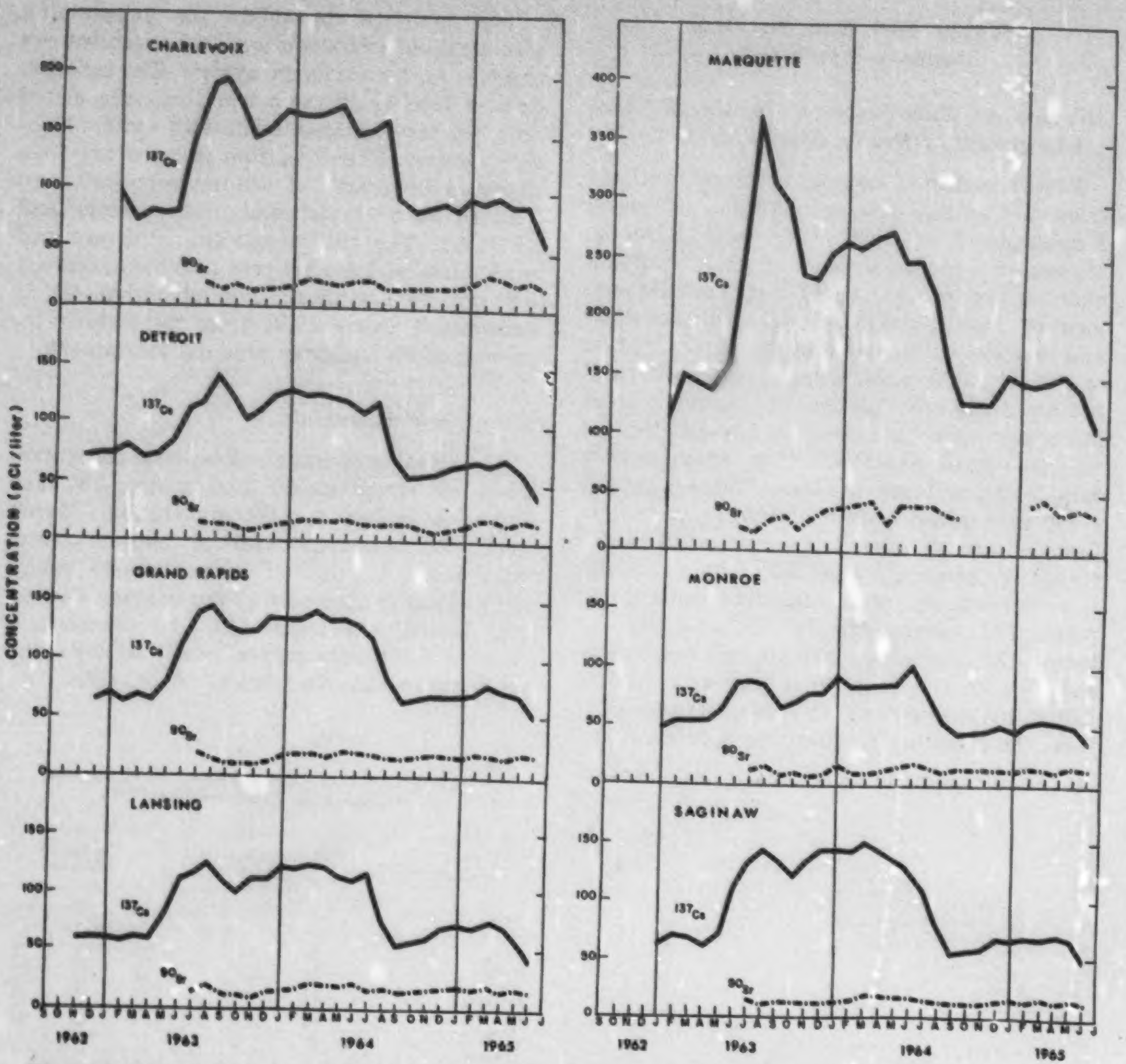

Figure 8. Monthly average concentrations of strontium-90 and cesium-137 in Michigan milk, 1962—June 1965

determined by gamma-scintillation spectrometry. The counting system consists of a 4- x 4-inch sodium iodide (thallium activated) crystal detector and a 400-channel pulse-height analyzer. The minimum levels of detectability are as follows: strontium-90, 9 pCi/liter; cesium-137, 5 pCi/liter; iodine-131, 14 pCi/liter; potassium-40, 80 pCi/liter; and barium-lanthanum-140, 4 pCi/liter.

Results and discussion

Table 8 presents the monthly average radionuclide concentrations in Michigan pasteurized milk for the period January to June 1965. The results are given for the seven major milk producing areas in the State.

During this period, iodine-131 and barium-lanthanum-140 concentrations in general remained below detectable levels.

To visualize general trends in strontium-90 and cesium-137 levels, monthly average concentrations are presented graphically in figure 8. Strontium-90 concentrations have remained fairly constant since the beginning of the program. Cesium-137 concentrations have followed a general decreasing trend since the peak observed in the summer of 1963.

5. New York Milk Network
January–March 1965

Division of Environmental Health Services
Department of Health, State of New York

Pasteurized milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 9)—are analyzed for their radionuclide content by the State of New York Department of Health. The samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, and barium-lanthanum–140 at all stations except Massena, where samples are composited biweekly, and at New York City, where a milk sample representing the total milk supply for 1 day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily composite is prepared from samples taken at a marketing point. The Albany samples are analyzed for iodine–131 and other gamma-emitting radionuclides. In the event that any city reports iodine–131 concentrations exceeding 100 pCi/liter, the sampling frequency is increased.

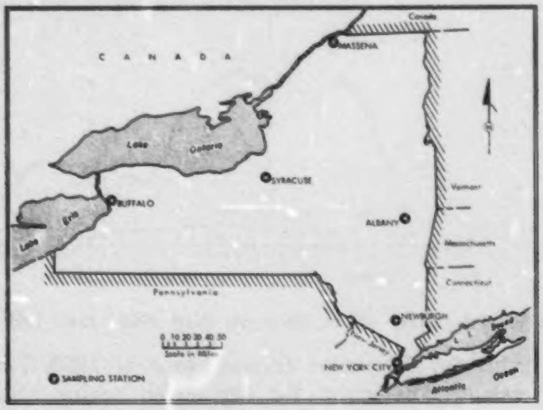

Figure 9. New York sampling stations

Analytical procedures

Gamma-emitting radionuclide concentrations in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (*5*) to the resultant spectral data.

The analytical procedure for determining strontium–89 and strontium–90 concentrations employs an ion exchange system. The collected cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution. The strontium isotopes are then gathered by means of sodium carbonate and isolated with ethylenediaminetetraacetic acid (EDTA). The radiostrontium is determined with a low-background beta counter having an 0.8 mg/cm^2 window. The strontium–90 is determined differentially from the 40-hour ingrowth of its daughter product, yttrium–90.

Results and discussion

The monthly average radionuclide concentrations of strontium–90 and cesium–137 are shown in table 9 for January through March 1965. Strontium–89 average concentrations were below 3 pCi/liter. Strontium–90 values showed a slight increase in this quarter. During this period, the iodine–131 and barium-lanthanum–140 concentrations remained below the minimum detectable level of 20 pCi/liter.

Table 9. Average radionuclide concentrations in New York milk, January–March 1965

Sampling station	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar
Albany	13	14	17	72	63	51
Buffalo	13	10	13	67	68	76
Massena	13	20	NS	92	102	104
Newburgh	17	18	19	79	65	NS
New York City	16	17	19	74	69	66
Syracuse	9	15	NS	56	63	60
Average	13.5	15.7	17.0	74.0	71.7	71.4

NS indicates no sample collected.

The cesium–137 and iodine–131 concentrations since September 1961 are represented in figure 10. Despite the slight increase shown in this report, the general long-range trend in cesium–137 concentrations since the atmospheric test ban treaty is one of decreasing levels. Seasonal variations have been apparent during this period.

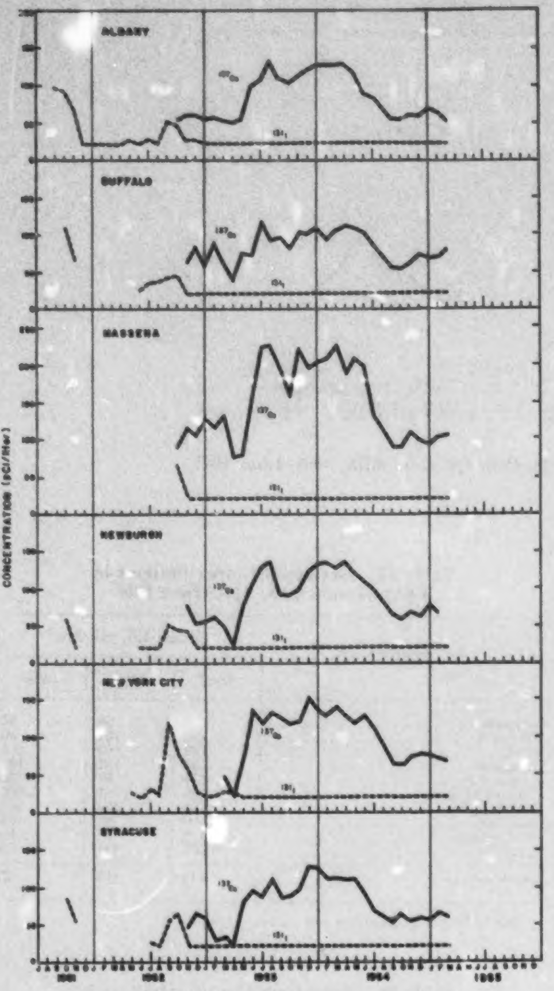

Figure 10. Cesium-137 and iodine-131 in New York milk, September 1961–March 1965

6. Pennsylvania Milk Network
April–June 1965

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 11). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analysis.

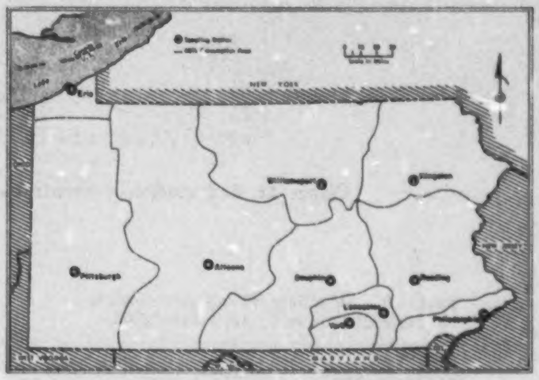

Figure 11. Pennsylvania milk sampling stations and milk consumption areas

Analytical procedures

Strontium-90 analyses have been carried out since April 1963. The chemical separation technique for strontium-90 is essentially the ion exchange method described by Porter, *et al.* (*2*). One liter of milk is passed through an ion exchange column; yttrium-90 is eluted from the resin and is counted in an automatic low-background proportional counter.

Iodine-131, cesium-137, and potassium-40 concentrations are determined by gamma scintillation spectrometry. The resultant gamma spectra are evaluated, using a matrix system of analysis.

Results

The average monthly strontium-90 concentrations in Pennsylvania pasteurized milk for April to June 1965 are shown in table 10, and presented graphically in figure 12.

Iodine-131 was observed in May and June 1965 as shown in table 11 and plotted in figure 12. Cesium-137 and potassium-40 concentrations are given in tables 12 and 13, respectively.

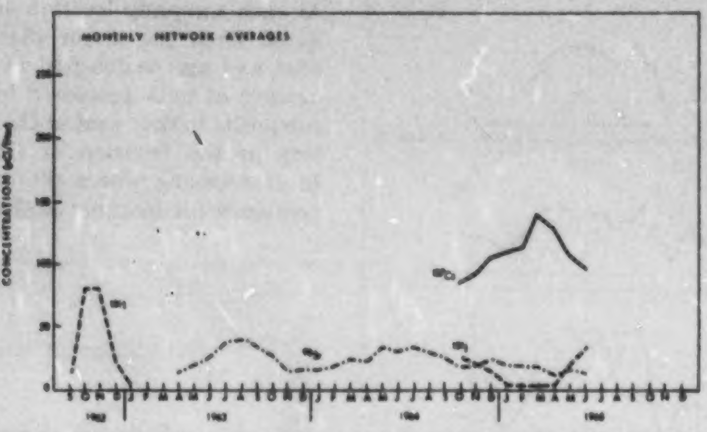

Figure 12. Radionuclide concentrations in Pennsylvania milk, 1962–June 1965

Table 10. Strontium-90 concentrations in Pennsylvania milk, April–June 1965

Sampling location	Strontium-90, pCi/liter		
	April	May	June
Altoona	17	16	13
Dauphin	15	18	14
Erie	17	20	19
Kingston	17	16	19
Lancaster	12	20	12
Philadelphia	16	19	15
Pittsburgh	27	23	23
Reading	17	20	13
Williamsport	13	17	13
York	19	19	12
State average	17	19	15

Table 11. Iodine-131 concentrations in Pennsylvania milk, April–June 1965

Sampling location	Iodine-131, pCi/liter		
	April	May	June
Altoona	<10	16	22
Dauphin	<10	40	24
Erie	<10	17	NA
Kingston	<10	34	30
Lancaster	<10	38	<10
Philadelphia	<10	<10	66
Pittsburgh	<10	10	45
Reading	<10	17	37
Williamsport	<10	14	40
York	<10	32	16
State average	<10	22	31

NA indicates no analysis performed.

Table 12. Cesium-137 concentrations in Pennsylvania milk, April–June 1965

Sampling location	Cesium-137, pCi/liter		
	April	May	June
Altoona	120	98	80
Dauphin	123	104	90
Erie	149	102	NA
Kingston	138	136	104
Lancaster	124	97	90
Philadelphia	136	99	106
Pittsburgh	133	134	108
Reading	120	100	105
Williamsport	118	94	89
York	130	110	79
State average	129	107	95

NA indicates no analysis performed.

Table 13. Potassium-40 concentrations in Pennsylvania milk, April–June 1965

Sampling location	Potassium-40, pCi/liter		
	April	May	June
Altoona	905	1,002	939
Dauphin	1,065	1,098	1,096
Erie	1,130	1,020	NA
Kingston	1,135	1,100	1,064
Lancaster	1,141	1,091	1,005
Philadelphia	1,080	1,083	1,111
Pittsburgh	1,110	1,113	1,059
Reading	1,113	1,004	1,124
Williamsport	945	1,002	1,004
York	1,020	1,154	1,039
State average	1,123	1,068	1,049

NA indicates no analysis performed.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
September 1962–November 1963	*March 1964*
December 1963–March 1964	*July 1964*
April–June 1964	*October 1964*
August–September 1964	*February 1965*
October–December 1964	*June 1965*
January–March 1965	*September 1965*

7. Washington Milk Network
January–June 1965

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 13 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. As this sampling program provides representation of a large percentage of the population's milk supply in the State, it would also provide a basis for initiating counter-measures. In addition to sampling milk from eight locations in Washington, milk from Northwest Idaho (Sandpoint) is included in the network, as this area forms a part of the Spokane milkshed. Several additional points are sampled from time to time.

Raw milk samples are normally collected monthly from individual tankers, but the sampling frequency is flexible. Increased sampling can be initiated immediately if the need should arise.

Analytical procedures

All milk samples are placed in a 2-liter stainless steel Marinelli beaker and gamma scanned for 100 minutes with a 512-channel pulse-height analyzer. This beaker, which is placed on a 3- x 3-inch NaI (Tl) crystal, provides equal sample thickness on all sides and top of the crystal. A 4 x 4 matrix is used to analyze the spectra and provide rapid quantitative results for iodine–131, barium–140, cesium–137, and potassium–40.

As a check of analyzer stability, daily 1-minute counts of cesium–137 are made with the same source. Gamma efficiencies and detectability limits are given in table 14 for this system.

Table 14. Beta and gamma efficiencies and limits of detectability

	Energy band (MeV)	Efficiency (percent)	Average background (pCi)	Limits of detectability (pCi)
Beta				
^{90}Y		37	0.6	0.24
Gamma				
^{40}K	1.37–1.55	0.18	2,277	335
^{131}I	0.33–0.40	4.20	300	20
^{137}Cs	0.62–0.72	2.60	246	30
^{140}Ba	0.46–0.57	3.50	326	30

Following gamma scanning, selected samples are analyzed for strontium–90. After the addition of strontium carrier, the milk proteins are precipitated with trichloroacetic acid. After filtration, oxalic acid is added to precipitate the alkaline earths as oxalates (pH 3.0). The oxalates are ashed, dissolved in 6*N* hydrochloric acid, and the pH is adjusted to 1.4. A double extraction is performed, using equal portions of 20 percent (by volume) di-(2-ethylhexyl) phosphoric acid (HDEHP) in toluene. This effectively removes rare-earth activity, including yttrium–90, leaving the strontium–90 in the

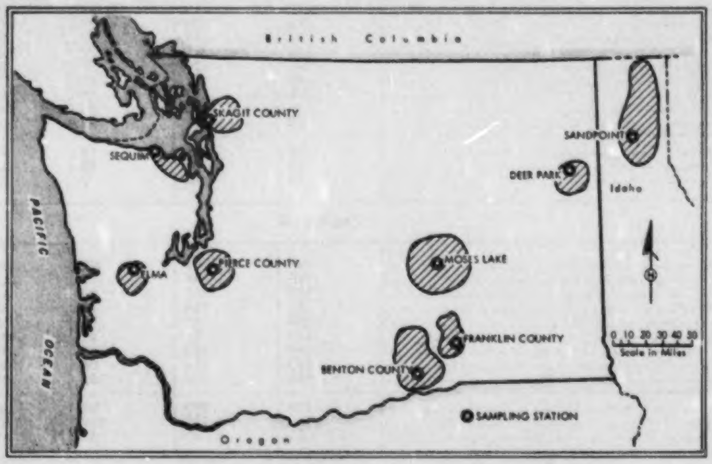

Figure 13. Washington milk sampling locations

100

sample. This sample is stored a minimum of 2 weeks to allow yttrium–90 to ingrow. Subsequently, the yttrium–90 is extracted with 5 percent (by volume) HDEHP in toluene. The organic layer is scrubbed with a HCl solution (pH 1.4) and back extracted with 3*N* HNO_3. The resulting nitric acid solution is evaporated and yttrium–90 counted. From this, the strontium–90 activity is calculated. The yttrium–90 counting is done in a low-background, gas-flow, internal proportional counter. The efficiency and detectability limit of the counter for yttrium–90 are given in table 14.

As a part of the laboratory's quality control program, some samples are split and analyzed several times. Split samples are also exchanged with State, Federal, and university laboratories for analysis and comparisons.

Results

Table 15 presents the monthly average radionuclide concentrations in Washington raw milk for January through June 1965. The results are given for representative production areas within the two major milksheds.

During this period fresh fission product concentrations remained below detectable levels, except in three samples in May and June, as shown in table 16. These samples are presumed to reflect the second mainland China atmospheric nuclear detonation of May 14, 1965.

Zinc–65 was observed in Benton and Franklin Counties on four occasions during this period (table 17). This nuclide has shown up routinely in these counties and results from irrigation of some pasture land with Columbia River

Table 15. Radionuclide concentrations, Washington milk, January–June 1965

(pCi/liter)

Sampling location	January	February	March	April	May	June
Potassium-40						
Benton County	NS	1,230	NS	1,340	1,130	NS
Deer Park	NS	1,220	1,280	1,230(3)	1,150(2)	1,160(2)
Elma	1,100	1,220	1,200	1,110	1,260(2)	1,170(2)
Franklin County	1,240	NS	1,260	1,110(2)	1,230	1,190(2)
Moses Lake	NS	1,230	1,240	1,210(3)	1,180(2)	1,150(2)
Pierce County	1,220	1,230	1,330	1,190	1,230(2)	1,130(2)
Sandpoint	NS	1,260	1,180	1,160(3)	1,270(2)	1,290(2)
Sequim	1,210	1,060	1,180	1,170	1,190(2)	1,170(2)
Skagit County	1,120	1,110	1,100	1,180	1,150(2)	1,130(2)
Average	1,180	1,200	1,220	1,190	1,200	1,170
Maximum	1,240	1,260	1,330	1,340	1,310	1,320
Minimum	1,100	1,060	1,100	1,060	1,110	1,030
Strontium-90						
Benton County	NS	10	NS	10	NA	NS
Deer Park	NS	24	24	20	22	22
Elma	23	21	17	12	37	29
Franklin County	10	NS	10	NA	9	7
Moses Lake	NS	10	9	10	10	7(2)
Pierce County	15	11	14	13	20	18
Sandpoint	NS	27	28	29	38(2)	31(2)
Sequim	19	20	24	21	19	11
Skagit County	22	21	22	19	25	26
Average	18	18	18	17	24	19
Maximum	23	27	28	29	38	32
Minimum	10	10	9	10	9	7
Cesium-137						
Benton County	NS	47	NS	59	27	NS
Deer Park	NS	148	137	135(3)	116(2)	96(2)
Elma	135	152	82	51	143(2)	113(2)
Franklin County	54	NS	43	55(2)	42	33(2)
Moses Lake	NS	61	50	50(3)	50(2)	32(2)
Pierce County	129	71	93	103	102(2)	98(2)
Sandpoint	NS	142	131	153(3)	152(2)	144(2)
Sequim	135	114	108	134	77(2)	51(2)
Skagit	124	135	102	101	101(2)	83(2)
Average	115	100	93	93	90	81
Maximum	135	152	137	164	159	145
Minimum	54	47	43	47	27	26

Key to symbols: ( ), number of samples in average.
NS, no sample collected.
NA, no analysis performed.

Table 16. Milk samples containing iodine-131

Sampling station	Date (1965)	Iodine-131 (pCi/liter)
Sandpoint	May 25	19
Moses Lake	June 1	16
Sandpoint	June 2	19

Table 17. Milk samples containing zinc-65

Sampling station	Date (1965)	Zinc-65 (pCi/liter)
Franklin County	January 6	110
Benton County	February 9	57
Franklin County	March 3	53

water which has been shown to contain this contaminant.

To visualize general trends in strontium–90 and cesium–137 concentrations in Washington milk, monthly average network concentrations are presented graphically in figure 14. These averages are highly artificial, as they are not weighted according to the volume of milk from each production area, nor do they take into consideration the absence of samples from several stations for a particular month.

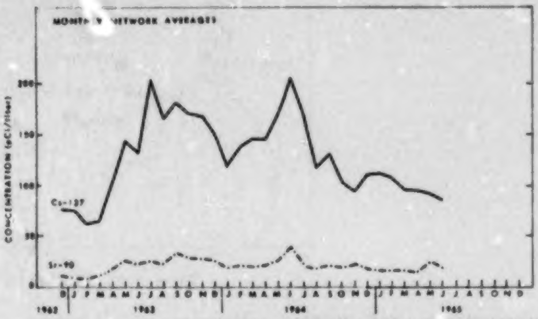

Figure 14. Radionuclides in Washington milk, 1962–June 1965

8. Canadian Milk Network[3]
July 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (see figure 15) can be chosen in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137, and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases, a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical methods

Since it represents a more sensitive method, radiochemistry, rather than gamma spectrometry, is used to determine iodine–131 (*6*). For the analysis of radiostrontium, carrier strontium is added to a 1-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle furnace at 450°C. and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-

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[3] Prepared from information and data in the June 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

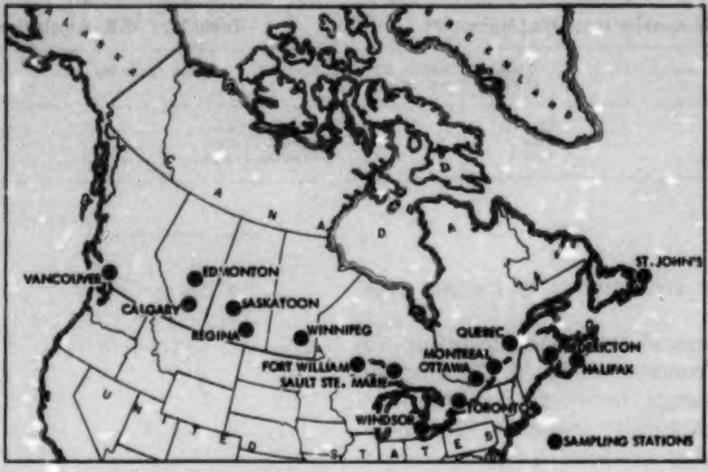

Figure 15. Canadian milk sampling stations

absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectrometry using a scintillation crystal and a multichannel pulse-height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- by 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radionuclide in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 18.

Table 18. Total error for various radionuclide concentrations in milk [a]

Nuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 19 presents monthly averages of strontium–90, cesium–137, and stable calcium and

Table 19. Stable elements and radionuclides in Canadian whole milk, July 1965[a]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.6	25.9	89
Edmonton	1.15	1.6	25.4	70
Ft. William	1.15	1.6	30.1	124
Fredericton	1.09	1.6	31.9	114
Halifax	1.18	1.6	31.4	102
Montreal	1.15	1.6	16.7	57
Ottawa	1.15	1.6	15.2	57
Quebec	1.16	1.6	31.8	94
Regina	1.00	1.6	23.1	58
St. John's, Nfld	1.22	1.6	53.4	204
Saskatoon	1.00	1.6	17.3	56
Sault Ste. Marie	1.16	1.7	23.2	126
Toronto	1.19	1.5	9.9	53
Vancouver	1.20	1.6	22.9	67
Windsor	1.25	1.6	9.4	38
Winnipeg	1.08	1.4	22.7	77
Average	1.14	1.6	25.0	87

[a] Due to insignificant levels of iodine-131 and strontium-89, the reporting of these radionuclides has been discontinued.

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potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

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9. Pan American Milk Sampling Program July 1965

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the Pan American Health Organization (PAHO) and the Public Health Service (PHS) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963, the program was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, additional stations were established in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde, and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma scintillation spectrometry. Strontium–89, strontium–90, and barium–140 are determined radiochemically (*5*). Analytical errors are discussed in the "Analytical Procedures, Pasteurized Milk Network," page 607.

Data presentation

Table 20 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations. The monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

Table 20. Stable element and radionuclide concentrations in milk, PAHO, July 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.10	1.5	<5	4	30
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	1.19	1.59	<5	9	190
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.10	1.6	<5	10	45
Venezuela:					
Caracas	1.23	1.46	<5	3	15

NS indicates no sample collected during this period.

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(*6*) DASGUPTA, A. K., and H. G. GREEN. A method for the radiochemical determination of iodine–131 in milk. RPD–23, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, JULY 1964–JULY 1965

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3*, *4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 grams of calcium per liter in PMN samples and a 1.0 gram daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average[2]. To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous 12-month average by 1 month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961). Price 20 cents.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflects temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

Table 1. Average radionuclide concentrations in milk for the 12-month periods,[a] July 1964–June 1965 and August 1964–July 1965

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)	
		July '64–June '65	Aug. '64–July '65	July '64–June '65	Aug '64–July '65	July '64–June '65	Aug. '64–July '65	July '64–June '65	Aug '64–July '65
Ala:	Montgomery	3	3	19	19	0	0	56	53
Alaska:	Palmer	3	3	18	17	1	1	78	73
Ariz:	Phoenix	3	3	5	5	0	0	24	24
Ark:	Little Rock	4	5	36	35	2	2	70	68
Calif:	Sacramento	3	3	7	7	1	1	31	30
	San Francisco	3	3	8	8	0	0	32	31
C. Z:	Cristobal	3	3	5	5	0	0	44	42
Colo:	Denver	3	3	18	18	1	1	77	71
Conn:	Hartford	3	3	18	17	0	0	91	85
Del:	Wilmington	3	3	19	18	2	2	76	71
D. C:	Washington	3	3	17	17	2	2	56	53
Fla:	Tampa	3	3	14	13	0	0	200	194
Ga:	Atlanta	3	3	27	26	1	1	92	86
Hawaii:	Honolulu	3	3	11	11	0	0	66	64
Idaho:	Idaho Falls	3	3	21	20	2	2	100	93
Ill:	Chicago	3	3	17	16	2	2	81	75
Ind:	Indianapolis	3	3	17	16	4	4	65	60
Iowa:	Des Moines	4	4	22	22	6	6	60	56
Kans:	Wichita	3	3	18	18	2	2	48	46
Ky:	Louisville	4	4	24	23	2	2	50	47
La:	New Orleans	5	5	43	41	2	2	88	83
Maine:	Portland	3	3	24	23	2	2	144	137
Md:	Baltimore	3	3	19	18	2	2	61	58
Mass:	Boston	3	3	25	23	0	0	142	133
Mich:	Detroit	3	3	16	15	3	3	81	75
	Grand Rapids	3	3	19	18	2	2	90	84
Minn:	Minneapolis	6	7	26	26	6	5	92	86
Miss:	Jackson	3	3	34	33	1	1	64	60
Mo:	Kansas City	5	5	23	22	8	8	50	47
	St. Louis	3	4	18	18	4	4	49	45
Mont:	Helena	3	3	18	18	3	3	97	92
Nebr:	Omaha	3	3	21	20	4	4	60	56
Nev:	Las Vegas	3	3	7	7	2	2	45	42
N. H:	Manchester	3	3	25	25	1	1	164	154
N. J:	Trenton	3	3	16	16	1	1	77	72
N. Mex:	Albuquerque	2	2	10	10	1	1	42	39
N. Y:	Buffalo	3	3	17	16	0	0	100	93
	New York	3	3	21	20	2	2	102	95
	Syracuse	[b] 3	3	[b] 16	16	[b] 1	1	[b] 86	82
N. C:	Charlotte	3	3	32	30	1	1	74	69
N. Dak:	Minot	6	7	49	47	2	2	124	115
Ohio:	Cincinnati	3	3	18	17	2	2	59	55
	Cleveland	3	4	18	18	2	2	82	76
Okla:	Oklahoma City	4	4	19	19	2	2	49	46
Ore:	Portland	3	3	24	23	0	0	111	98
Pa:	Philadelphia	3	3	17	17	0	0	74	68
	Pittsburgh	3	4	25	24	2	2	101	94
P. R:	San Juan	3	3	11	11	1	1	56	53
R. I:	Providence	3	3	20	19	0	0	108	102
S. C:	Charleston	3	3	29	29	1	1	98	95
S. Dak:	Rapid City	5	7	33	30	3	4	119	110
Tenn:	Chattanooga	4	4	33	32	1	1	71	67
	Memphis	3	4	26	25	2	2	46	44
Tex:	Austin	3	3	8	8	1	2	29	29
	Dallas	3	3	18	17	1	1	42	40
Utah:	Salt Lake City	3	3	23	22	2	2	126	117
Vt:	Burlington	3	3	22	21	2	2	118	111
Va:	Norfolk	4	4	16	16	2	3	64	60
Wash:	Seattle	3	3	24	23	0	0	115	104
	Spokane	3	3	25	25	0	0	104	97
W. Va:	Charleston	4	4	19	19	2	2	45	43
Wis:	Milwaukee	3	3	15	14	3	3	90	85
Wyo:	Laramie	3	3	16	15	2	2	77	71
Network average		3	3	20.3	19.6	2	2	80	75

[a] Annual averages for barium-140 at each station were <2 pCi/liter.

[b] Annual averages were computed on basis of 48 weekly averages.

(*2*) NATIONAL COMMITTEE ON RADIATION PROTECTION. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure. National Bureau of Standards Handbook 69. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (June 5, 1959).

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CESIUM-137 IN FRESHWATER FISH: HUMAN CONSUMPTION AND BODY BURDEN CONSIDERATIONS[1]

P. F. Gustafson[2]

Measurements of cesium-137 in freshwater fish made at Argonne National Laboratory during the first half of 1965 indicated relatively high concentrations (*1*). The fish examined were purchased in food markets in the Chicago area and, for the most part, were fresh or frozen dressed ready for cooking. Frozen fish may be kept for a considerable time without spoilage; hence, those samples investigated may have included fish actually caught during the 1964 season, or perhaps even earlier. The work of Häsänen and Miettinen in Finland showed comparable or slightly lower levels in freshwater fish caught during 1961 and 1962 (*2*). More recently Kolehmainen *et al.* reported increased concentrations in fish from the same lakes during 1963 and early 1964 (*3*). Analyses of the Chicago portion of the foods collected as part of the Tri-City Diet Sampling Program showed exceptionally high cesium-137 concentrations in fish on several occasions prior to 1965 (*4*). The fish purchased in the Tri-City study were usually ocean varieties, with ocean perch, cod, and halibut predominating. When freshwater fish were included, they were mixed with the other varieties and the homogenized batch of fish was measured for cesium-137. Thus the present observation of high cesium-137 levels in freshwater fish need not be considered a sudden or recent occurrence; nor is there any reason to presume it to be a local phenomenon. Due to the efficient processing and distribution of fish and fish products, freshwater fish containing similar concentrations of cesium-137 should be readily available on the commercial market throughout most of the United States and Canada.

Cesium-137 concentrations found in several of the more important freshwater species ranged from 180 pCi/kg (wet weight) in whitefish, to more than 4,000 pCi/kg in some of the larger predators such as lake trout and pike, as shown in table 1. For comparison, the levels seen in a number of marine species, ranging from 10 to approximately 100 pCi/kg, are also listed in table 1. Although not all commercially important varieties of freshwater fish have as yet been examined, table 1 clearly indicates that in every case thus far, the concentration of cesium-137 was substantially greater in freshwater than in marine species.

Table 1. Range of cesium-137 and potassium concentrations and ^{137}Cs/K ratio observed in freshwater and ocean fish purchased during January to August 1965

Species[1]	^{137}Cs (pCi/kg wet weight)	Potassium (g/kg wet weight)	^{137}Cs/K ratio (pCi/g)
Freshwater fish			
Lake trout	2,210–4,230	2.49–3.50	890–1,230
Northern pike	1,170–4,100	2.47–3.58	440–1,210
Whitefish	180–2,800	2.68–3.77	55–800
Lake perch	330–1,105	2.96–3.40	110–390
Chubs[2]	680–1,400	3.10–3.50	220–430
Smelts	325–430	2.60–3.30	125–160
Ocean fish			
Cod	29–43	3.90–4.17	7–10
Haddock	53–66	3.70–4.02	14–16
Halibut	62–69	5.26–5.35	12–13
Flounder	24–30	2.88–3.10	8–12
Ocean perch	32–56	3.06–3.11	10–18
Ocean catfish	43–59	4.04–4.15	11–14
Red snapper	12–21	1.76–1.95	7–11
Salmon[3]	71–93	3.51 3.66	20–25

[1] The common or commercial names of fish are used here instead of the scientific (taxonomic) names because of the difficulty in determining the latter with any precision in the case of frozen, dressed fish.

[2] Smoked chubs were analyzed.

[3] Salmon also contained concentrations of manganese-54 comparable to that of cesium-137.

The capacity of various members of a freshwater aquatic system to concentrate cesium-137 to a high degree was illustrated in the work of Pendleton and Hanson in 1958, when they investigated a number of species of aquatic animals living in a freshwater pond contaminated with cesium-137 (*5*). The most important factor governing the uptake of cesium-137 in going from one trophic level to another appears to be the ^{137}Cs/K ratio itself. Because of the higher concentration of potassium in sea water (approximately 380 parts per million) relative to that in fresh water (a few parts per million), equal concentrations of cesium-137 in the two media will result in a higher ^{137}Cs/K ratio in fresh water. Pendleton *et al.* have ob-

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[1] Work supported by the U.S. Atomic Energy Commission.

[2] Dr. Gustafson is an associate physicist with the Division of Biological and Medical Research, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60440.

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served on the order of a threefold increase in the ^{137}Cs/K ratio in proceeding from one trophic level to the next higher level in both freshwater and terrestrial environments (*6*). These authors attribute the increase in ratio to the longer biological half-life of cesium relative to potassium. Thus, the cesium-137 concentration in a specific fish should be a function of the ^{137}Cs/K ratio in the water and the position of the fish on the trophic scale.

Relative consumption of fish

The immediate interest in the cesium-137 levels in freshwater fish relates to the concentration of cesium-137 in the human body which may result from the eating of such fish. In general, the U.S. population is not heavily dependent upon aquatic food (*i.e.*, fish) as a source of protein. This is illustrated by statistics for 1964 which showed that the average annual per capita consumption of fish in the United States was 4.8 kg, placing it fourth (in terms of mass consumed) in dietary importance as a protein source after milk (187 kg), meat (77 kg), and poultry (including turkey, 17 kg) (*7*). The bulk of fish eaten in this country come from the ocean; of the nearly one billion kg of fish actually consumed by man in the United States in 1964, only 4 to 5 percent (making some allowance for fish caught by sport fishermen) were freshwater fish (*8*). It should be emphasized, however, that the total gross weight of fish caught by U.S. fishermen, and imported, amounted to 5.7 billion kg in 1964 (*8*). The 4.6 billion kg of nonedible fish and fish products stayed nonetheless within the broader confines of the food chain, since fish meal is used as an animal and poultry feed, and fish fertilizer is used in agriculture.

Cesium-137 intake from fish

The cesium-137 level in the composite Chicago diet has been determined quarterly since April 1961 as part of the Argonne contribution to the Tri-City program. In April 1965, the adult intake of cesium-137 according to this diet was 140 pCi/day contained in 1.85 kg of food. In this particular sampling, the fish portion of the diet consisted of halibut, cod, haddock, sole, ocean perch, pike, trout, and whitefish, the latter three species being from fresh water. The arithmetic average concentration of cesium-137 in all fish contributes a daily intake of 8 pCi/day, assuming an annual consumption of 8 kg of fish. The excess over the national average, 8 kg versus 4.8 kg, is presumably due to the proximity of New York City, Chicago, and San Francisco to an abundant supply of fish. By using the April 1965 concentrations of cesium-137 instead of taking the arithmetic average, assuming that 5 percent of the daily intake came from freshwater fish (average concentration of 930 pCi/kg), and the other 95 percent came from ocean fish (average concentration of 27 pCi/kg), then the daily intake due to fish would be less than 2 pCi/day.

The important fact to bear in mind, however, is that the above are average figures, and some population groups may eat substantially larger amounts of fish. There are also individual persons who eat fish in preference to meat or poultry. In addition to such dietary preferences, one must consider religious, cultural, and health factors which may also cause an increase above the national average. Proximity to an abundant supply of fish has already been cited as a reason for increased intake of cesium. Further influence in this direction can be visualized in remote areas where fishing is the principal means of livelihood. Of particular interest in regard to cesium-137 would be fishing camps and processing plants located along freshwater lakes and streams in remote localities.

Changes in the diet can be made which will produce an increase in freshwater fish consumption, and in turn may cause an increase in the cesium-137 whole-body burden. The relationship between the level of cesium-137 in the diet and that in man, under near equilibrium conditions, has been investigated using the Tri-City diet results and whole-body counter measurements made at Argonne. The average cesium-137 intake for Chicago adults during the first 9 months of 1964 was computed to be 201.5 pCi/day, and the corresponding average potassium intake was 4.5 g/day, resulting in an average ratio in the entire diet of 44.8 pCi/g K. The average daily potassium intake observed during 1962 through 1964 was 4.5 ± 0.39, and a value of 4.5 g/day will be used in all subsequent calculations of ^{137}Cs/K values. In September 1964 whole-body measurements by Miller showed an average ^{137}Cs/K ratio of 139.8 pCi/g K in 8 Argonne employees (*9*).

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The increase ratio shown in equation 1,

$$\frac{(^{137}\text{Cs/K})\text{ man}}{(^{137}\text{Cs/K})\text{ diet}}=\frac{139.8}{44.8}=3.12, \qquad \text{Eq. 1}$$

was 3.12, in accord with the findings of Pendleton *et al.* (*6*), referred to previously. This would seem to indicate that the factor of 3 increase in ^{137}Cs/K ratio applies also in the case of man relative to his diet, and will be used in subsequent calculations.

As mentioned previously, in April 1965 the cesium–137 content of the composite adult diet in the Chicago area was 140 pCi/day; this, coupled with a potassium intake of 4.5 g, yields a ^{137}Cs/K ratio of 31.1 pCi ^{137}Cs/g K. The cesium–137 and potassium intakes from various categories of foodstuffs, as well as the ^{137}Cs/K ratio for each component, are shown in table 2. Milk, meat, and grain products account for 80 percent of the daily intake of cesium–137 and nearly 50 percent of the daily intake of potassium. Even in the case of mixed fish, the ^{137}Cs/K ratio in fish is higher than any of the other diet components, being followed by grain products, meat, and milk, in that order.

Table 2. Cesium-137, potassium, and ^{137}Cs/K ratio in the adult Chicago diet, April 1965

Diet component	Cesium-137 (pCi/day)	Potassium (g/day)	^{137}Cs/K, (pCi/g K)
Milk	47.2	1.09	43.3
Meat	36.2	0.63	57.5
Grain products	31.7	0.43	73.7
Fruit	11.1	0.66	16.8
Fish (mixed)	8.0	0.09	88.9
Vegetables	3.6	1.39	2.6
Poultry	1.5	0.12	12.5
Eggs	0.8	0.07	11.4
Total	140.1	4.48	[a]31.2

[a] Weighted total on the basis of the amount of each component consumed per day.

The ^{137}Cs/K ratio in man at or near equilibrium with a diet containing a ratio of 31.1 pCi/g K would be approximately 100 pCi/g K. Assuming a standard 70 kg man to contain 140 g of potassium, a level of 100 pCi/g K corresponds to a total cesium–137 body burden of 14,000 pCi or 14 nCi (nanocuries).[3] This cesium–137 body burden is in accord with whole-body measurements made slightly prior to this time (*10*).

Consider an individual who divides the protein intake (81 kg/year) assumed to come from fish (8 kg/year) and meat (73 kg/year) equally between fish and meat, other diet components remaining the same. If all the fish were from fresh water, the cesium–137 intake would become 218 pCi/day, and the ^{137}Cs/K ratio would be 48.8 pCi/g. Limiting the entire protein intake of 81 kg/year to freshwater fish would raise the cesium–137 intake to 302 pCi/day, with a ^{137}Cs/K ratio of 67.5 pCi/g, which would lead to a body burden of 28 nCi at equilibrium, or double the observed level in the Chicago population in April 1965.

An annual consumption of 81 kilograms of meat and fish amounts to slightly under a half-pound of protein per day. People on a less varied diet, surrounded by an ample supply of fish and little else, might be expected to eat more than a half-pound of fish per day. Miettinen *et al.*, in studying the Lapland diet, found that the male Lapp eats on the average more than 500 grams of meat and fish per day (*11*). It should also be borne in mind that the concentration of 930 pCi/kg of wet weight observed in freshwater fish in April 1965 is surpassed in a number of instances, as shown in table 1. The mean value of several dozen northern pike from Red Lake, Minnesota, measured at Argonne was approximately 3,000 pCi/kg (approximately 1,000 pCi/g K). Fish at this cesium–137 level eaten in the amount of *1 pound per day* would lead to an equilibrium body burden in the standard man of 420 nCi. Cesium–137 concentrations in freshwater fish, higher by factors of 3 to 6, have been observed by Canadian and Finnish investigators during 1964 and 1965 (*3, 12*).

Evidence of the importance of freshwater fish as a dietary source of cesium–137 has come from the studies of Lapps and Eskimos. These people obtain much of their cesium–137 from eating caribou and/or reindeer. However, fish are also plentiful and, more importantly, available on a year-round basis. Miettinen found in 1962 that 10–15 percent of the cesium–137 intake in Lapps came from fish (no differentiation between freshwater and ocean fish was made) at a time when the whole-body burdens were 200–400 nCi, thus implying that 20 to 60 nCi came from fish (*11*). In 1964 Bird *et al.* noted two segments of the Canadian Eskimo population whose body burdens were several hundred nCi but who ate little or no caribou or

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[3] Editor's note: For reference, NBS Handbook 69 (*13*) lists the following Maximum Permissible Body Burdens of ^{137}Cs:
For radiation workers (occupational), 30 μCi.
For individuals in the general population, 3 μCi.
For the average person in the general population, 1 μCi.

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reindeer (*14*). It would thus appear that even in the case of persons eating caribou and reindeer, freshwater fish are making a substantial contribution to the total body cesium–137 burden, even though the levels of cesium–137 in fish observed thus far are lower than those found in caribou and reindeer.

There is thus strong suggestive evidence that body burdens of the order of 0.1 μCi (100 nCi) could be attained by people not dependent upon caribou or reindeer for food, but subsisting to a large extent upon fish and other natural forms such as deer or other mammals which might also be expected to have substantial concentrations of cesium–137. Interest in these fish-eating populations should approach that being given to the Lapps and Eskimos, particularly since their number may well exceed that in the caribou-reindeer eating population. The fish-eaters thus comprise a potentially important subgroup of the population and more information about them should be obtained.

Having established the existence of relatively high cesium–137 levels in freshwater fish, a further question is, how do these levels change with time, and in particular, what future levels may we expect? The biologic half-time of cesium in fish is short (5–10 days) (*15*); thus, changes in the cesium–137 content in the diet of the fish will cause rapid changes in the body burden of fish. There are seasonal changes in the eating habits of fish, and there are also changes in the deposition of cesium–137 throughout the year. Analyses of fish specimens collected over past years—particularly the crucial years 1957–1964—would be invaluable in this regard. Such data used in conjunction with cesium–137 deposition and accumulation data could establish future trends on the basis of past behavior.

The presence of readily measurable quantities of cesium–137 in freshwater fish makes it possible to conduct a variety of investigations of environmental contamination, not all of which relate solely to radioactive contamination. The most obvious opportunity is probably that of studying the freshwater ecosystem itself. Some groups in the fish-eating population offer perhaps an unmatched opportunity to study a remote, nonmobile population largely unaffected by the averaging and dilution processes inherent in modern food technology, yet very strongly affected by the surrounding environmental factors. A detailed and imaginative investigation could provide the basis for the sound evaluation of the mechanisms and effects of localized (in the broad sense) contamination—a matter of current and lasting concern to radiation surveillance and protection groups. Furthermore, such an investigation, involving a variety of disciplines, could yield much basic information on the movement, uptake, retention, and elimination of contaminants in a real situation which could not be duplicated in the laboratory.

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MAY 1965

Division of Water Supply and Pollution Control Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–8*).

Sampling procedures

The participating agencies collect 1-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short term increases in radioactivity from current or recent nuclear tests or events.

Analytical methods

The analytical method for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*9*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Normally, samples are counted within 2 weeks following collection or within 1 week after compositing. The decay of activity is followed for each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on the recount are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Results

Table 1 presents the most recent results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative locations, the first stations listed being closest to the head-

Table 1. Radioactivity in raw surface waters, May 1965[a]

(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa	1	5	6	0	0	0
Animas River:						
Cedar Hill, N. Mex	7	7	14	1	1	2
Apalachicola River:						
Chattahoochee, Fla	—	—	—	—	—	—
Arkansas River:						
Coolidge, Kans	273	37	310	96	23	119
Ponca City, Okla	37	16	53	13	3	16
Fort Smith, Ark	15	18	33	5	2	7
Little Rock, Ark	219	15	234	30	1	31
Pendleton Ferry, Ark	8	15	23	2	2	4
Atchafalaya River:						
Morgan City, La	48	11	59	20	1	21
Bear River:						
Preston, Idaho	2	12	14	1	2	3
Big Horn River:						
Hardin, Mont	69	20	89	13	7	20
Big Sioux River:						
Sioux Falls, S. Dak	7	33	40	1	5	6
Chattahoochee River:						
Atlanta, Ga	—	—	—	—	—	—
Lanett, Ala	2	4	6	0	0	0
Columbus, Ga	0	4	4	0	0	0
Chena River:						
Fairbanks, Alaska	5	9	14	1	1	2
Clearwater River:						
Lewiston, Idaho	3	3	6	<1	0	<1
Clinch River:						
Clinton, Tenn	1	3	4	0	0	0
Kingston, Tenn	—	—	—	—	—	—
Colorado River:						
Loma, Colorado	114	15	129	123	3	126
Page, Ariz	2	25	27	0	9	9
Boulder City, Nev	—	—	—	—	—	—
Parker Dam, Calif-Ariz	2	22	24	0	9	9
Yuma, Ariz	1	31	32	0	0	0
Columbia River:						
Northport, Wash	1	4	5	0	1	1
Wenatchee, Wash	1	5	6	0	1	1
Pasco, Wash	21	105	126	0	1	1
McNary Dam, Ore	37	96	133	1	0	1
Bonneville, Ore	—	—	—	—	—	—
Clatskanie, Ore	90	48	138	1	0	1
Connecticut River:						
Wilder, Vt	1	5	6	0	0	0
Northfield, Mass	24	4	28	4	0	4
Enfield Dam, Conn	2	5	7	1	0	1
Coosa River:						
Rome, Ga	2	6	8	<1	0	<1
Cumberland River:						
Cheatham Lock, Tenn	0	5	5	1	0	1
Cuyahoga River:						
Cleveland, Ohio	3	23	26	1	1	2
Delaware River:						
Martins Creek, Pa	1	12	13	0	0	0
Trenton, N.J	1	5	6	0	0	0
Philadelphia, Pa	1	4	5	0	0	0
Escambia River:						
Century, Fla	1	4	5	0	0	0
Great Lakes:						
Duluth, Minn	1	3	4	0	0	0
Sault Ste. Marie, Mich	4	5	9	0	0	0
Milwaukee, Wis	0	6	6	0	0	0
Gary, Ind	1	6	7	0	0	0
Port Huron, Mich	0	8	8	0	0	0
Detroit, Mich	0	6	6	0	0	0
Buffalo, N.Y	—	—	—	—	—	—
Green River:						
Dutch John, Utah	1	22	23	0	4	4
Hudson River:						
Poughkeepsie, N.Y	2	6	8	0	0	0
Illinois River:						
Peoria, Ill	12	15	27	3	2	5
Grafton, Ill	—	—	—	—	—	—
Kanawha River:						
Winfield Dam, W. Va	1	5	6	0	0	0
Kansas River:						
De Soto, Kans	7	15	22	2	3	5
Klamath River:						
Keno, Ore	1	17	18	0	1	1
Little Miami River:						
Cincinnati, Ohio	2	7	9	0	0	0
Maumee River:						
Toledo, Ohio	5	16	21	1	2	3
Merrimack River:						
Lowell, Mass	—	—	—	—	—	—
Mississippi River:						
St. Paul, Minn	5	29	34	1	4	5
Dubuque, Iowa	5	15	20	1	1	2
Burlington, Iowa	4	16	20	1	1	2
E. St. Louis, Ill	11	16	27	2	3	5
Cape Girardeau, Mo	—	—	—	—	—	—
W. Memphis, Ark	5	16	21	1	1	2
Vicksburg, Miss	13	12	25	3	0	3
Delta, La	16	13	29	5	1	6
New Roads, La	10	11	21	3	0	3
New Orleans, La	12	12	24	5	1	6
Missouri River:						
Williston, N. Dak	7	18	25	2	4	6
Bismarck, N. Dak	16	20	36	6	4	10
Yankton, S. Dak	2	27	29	0	6	6
Omaha, Nebr	26	19	45	7	4	11
St. Joseph, Mo	71	20	91	18	3	21
Kansas City, Kans	14	24	38	5	5	10
Missouri City, Mo	—	—	—	—	—	—
St. Louis, Mo	30	23	53	7	2	9
Monongahela River:						
Pittsburgh, Pa	1	5	6	0	1	1
North Platte River:						
Henry, Nebr	11	32	43	1	22	23
Ohio River:						
Toronto, Ohio	1	8	9	0	0	0
Addison, Ohio	—	—	—	—	—	—
Huntington, W. Va	—	—	—	—	—	—
Cincinnati, Ohio	0	5	5	0	0	0
Louisville, Ky	3	6	9	0	1	1
Evansville, Ind	9	7	16	2	0	2
Cairo, Ill	7	8	15	1	1	2
Ouachita River:						
Bastrop, La	—	—	—	—	—	—
Pend Oreille River:						
Albeni Falls Dam, Idaho	3	4	7	0	<1	<1
Platte River:						
Plattsmouth, Nebr	307	22	329	79	3	82
Potomac River:						
Williamsport, Md	1	3	4	0	0	0
Great Falls, Md	1	5	6	0	0	0
Washington, D. C	1	4	5	0	0	0
Rainy River:						
Baudette, Minn	3	20	23	0	<1	<1
International Falls, Minn	2	18	20	0	0	0
Raritan River:						
Perth Amboy, N. J	—	—	—	—	—	—
Red River, North:						
Grand Forks, N. Dak	12	35	47	3	3	6
Red River, South:						
Denison, Tex	1	24	25	0	2	2
Index, Ark	—	—	—	—	—	—
Bossier City, La	2	17	19	0	3	3
Alexandria, La	16	15	31	7	1	8
Rio Grande:						
Alamosa, Colo	—	—	—	—	—	—
El Paso, Tex	6	18	24	1	5	6
Laredo, Tex	46	15	61	10	2	12
Brownsville, Tex	—	—	—	—	—	—
Roanoke River:						
John H. Kerr Resr. & Dam, Va	1	5	6	0	0	0
Sabine River:						
Ruliff, Texas	6	12	18	1	0	1
Sacramento River:						
Greens Landing, Calif	—	—	—	—	—	—
St. Lawrence River:						
Massena, N. Y	3	8	11	0	0	0
San Joaquin River:						
Vernalis, Calif	4	6	10	1	0	1
San Juan River:						
Shiprock, N. Mex	25	11	36	8	2	10
Savannah River:						
North Augusta, S. C	2	6	8	0	0	0
Port Wentworth, Ga	3	8	11	<1	0	<1
Schuylkill River:						
Philadelphia, Pa	1	9	10	0	0	0
Shenandoah River:						
Berryville, Va	—	—	—	—	—	—
Ship Creek:						
Anchorage, Alaska	—	—	—	—	—	—
Snake River:						
Payette, Idaho	3	7	10	1	1	2
Wawawai, Wash	3	4	7	<1	0	<1
Ice Harbor Dam, Wash	1	4	5	0	0	0
South Platte River:						
Julesburg, Colo	88	58	146	18	36	54

See footnote at end of table.

Table 1. Radioactivity in raw surface waters, May 1965[a]—Continued

Average concentrations in pCi/liter

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dis-[illegible]	Total
Spokane River:						
Post Falls Dam, Idaho	1	2	3	0	0	0
Susquehanna River:						
Sayre, Pa	1	10	11	0	0	0
Conowingo, Md	1	3	4	0	0	0
Tennessee River:						
Lenoir City, Tenn	1	4	5	0	0	0
Chattanooga, Tenn	1	10	11	0	0	0
Bridgeport, Ala	—	—	—	—	—	—
Pickwick Landing, Tenn	1	7	8	0	0	0
Tombigbee River:						
Columbus, Miss	2	5	7	1	0	1
Truckee River:						
Farad, Calif	0	4	4	0	0	0
Verdigris River:						
Nowata, Okla	173	16	189	54	0	54
Wabash River:						
New Harmony, Ind	16	10	26	3	1	4
Willamette River:						
Portland, Ore	1	2	3	0	0	0
Yakima River:						
Richland, Wash	1	4	5	0	0	0
Yellowstone River:						
Sidney, Mont	52	15	67	16	3	19
Maximum	307	105	329	123	36	126
Minimum	0	2	3	0	0	0

[a] These data are preliminary: reanalysis of some samples may be made and additional analyses not completed at the time of this report may become available. For final data, one should consult the system's annual report.

Dashes indicate no sample.

waters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

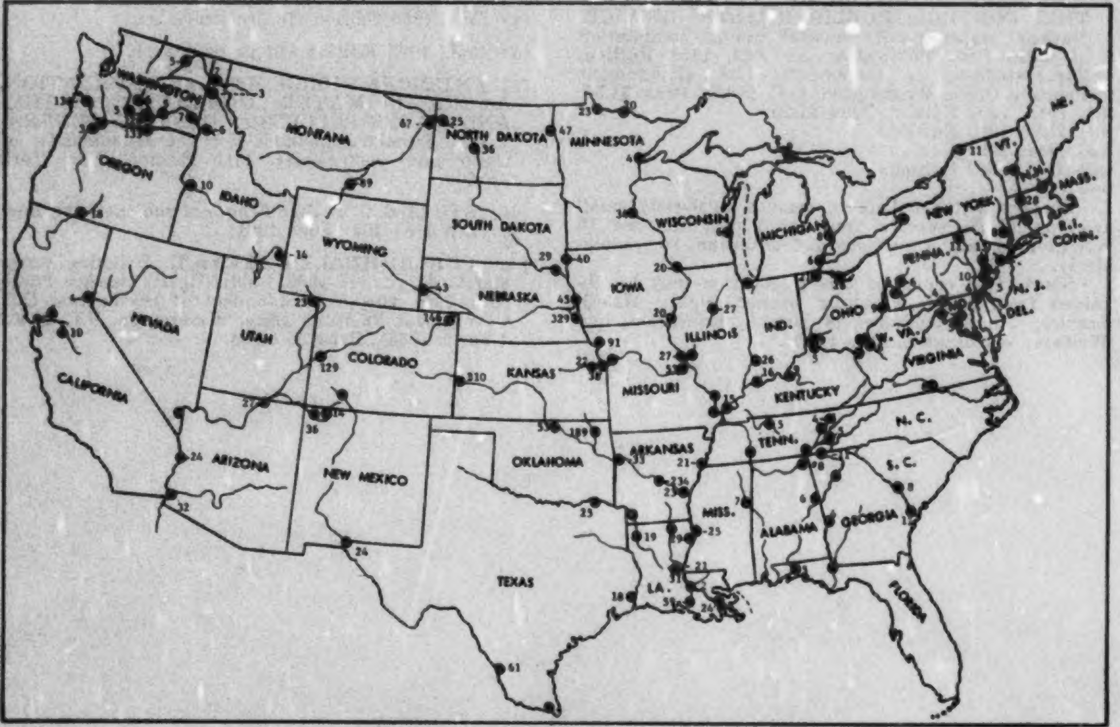
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LA.
WISCONSIN
ILLINOIS
MISS.
MICHIGAN
IND.
KENTUCKY
TENN.
ALABAMA
OHIO
W. VA.
VIRGINIA
N. C.
S. C.
GEORGIA
FLORIDA
PENNA.
NEW YORK
N. J.
DEL.
VT.
N.H.
MASS.
R.I.
CONN.
ME.
329
189
129
210
144
91
89
67
63
61

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, May 1965

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It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha and/or beta activity whereas fallout primarily contributes additional beta activity.

The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*10*). The Public Health Service Drinking Water Standards state that in the absence of alpha emitters and strontium-90, a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*11*).[1]

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

Table 2. Summary

Station	Sample activity	Remarks
Arkansas River Coolidge, Kans.	α, Susp. 884 pCi/liter β, Susp. [illegible] pCi/liter on sample collected 5/24/65, analysed in triplicate; median reported.	Due to flood condition, sample contained 14,930 mg/l suspended solids.
Little Rock, Ark.	α, Susp. 30 pCi/liter β, Susp. 219 pCi/liter	Sample contained 4,288 mg/l suspended solids.
Colorado River Loma, Colo.	α, Susp. 123 pCi/liter β, Susp. 114 pCi/liter	Sample contained only 720 mg/l suspended solids. Level returned to normal <10 pCi/l on next sample.
Missouri River St. Joseph, Mo.	α, Susp. 18 pCi/liter β, Susp. 71 pCi/liter	Sample contained 1,062 mg/l suspended solids.
Platte River Plattsmouth, Neb.	Average for month α, Susp. 79 pCi/liter β, Susp. 307 pCi/liter	Average for month contained 5,128 mg/l suspended solids.
Verdigris River Nowata, Okla.	α, Susp. 54 pCi/liter β, Susp. 173 pCi/liter Analysed in triplicate; median reported.	Sample contained 2,304 mg/l suspended solids.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

RADIOACTIVITY IN SURFACE WATERS OF THE COLORADO RIVER BASIN, 1962-1964

Colorado River Basin Water Quality Control Project
Division of Water Supply & Pollution Control, PHS

In view of accumulated data on radioactive contamination of Colorado River Basin surface waters and river sediments by uranium milling waste discharges to the stream environment, a conference on uranium milling wastes was held in October 1957 at Cortez, Colorado. The conference was attended by representatives of the States of Arizona, New Mexico, Colorado, Utah, and the U.S. Public Health Service. At this conference, a Radium Monitoring Network was suggested to provide needed continuous data or radioactivity contributed by uranium mining and milling operations to the Colorado River Basin surface waters. The envisioned purpose of this network was to define both natural and industrial sources of radioactive pollution, and to measure either improvement or degradation of surface waters due to the continuance or abatement of these pollution sources. Accordingly, a Radium Monitoring Network was established when the U.S. Public Health Service Colorado River Basin Water Quality Control Project was organized in 1960 under provisions of the Federal Water Pollution Control Act. The original network of 23 stations became operational at the end of 1961, was expanded to 27 stations (figure 1), and has recently been reduced to 21 active stations. Data collected through this system are reported seminannually to the Project conferees and other interested parties and agencies, and a summary of data collected through 1963 was published in November 1964 (*1*).

Sampling procedures

Seven of the original network stations were automatic collection stations and the remainder were grab sampling stations. Depending upon the type of data required and physical location limitations encountered at each station, grab samples are collected 1 to 6 times weekly and automatic samplers collect a 21-ml sample every hour. The samples are sent "as is" to the Colorado River Basin Project Laboratory where they are composited into weekly or monthly composite samples, filtered, and the filtrate analyzed for the desired radionuclides.

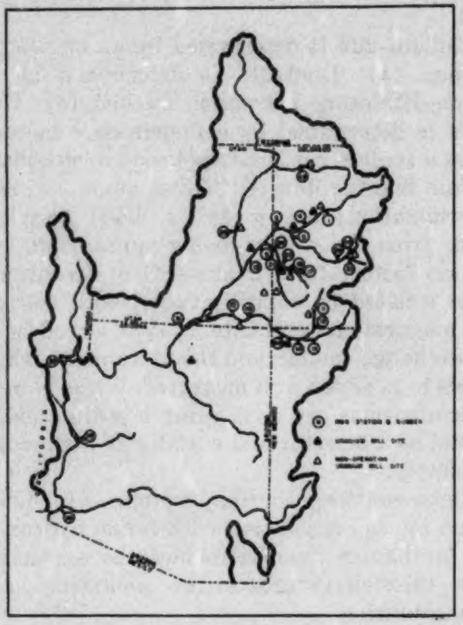

Figure 1. Colorado River Basin radium monitoring network

Radium–226, with the lowest recommended Maximum Permissible Concentration in water of all radionuclides (*2*), has been the radioactive contaminant of greatest concern in uranium mill discharges (*3*). Consequently, initial and primary emphasis was placed on the analysis for radium–226 only. In October 1963, uranium determinations were added, and beginning in July 1963, samples from selected stations were combined into quarterly composites to be gamma-scanned and analyzed for gross alpha, gross beta, lead–210, thorium alpha, and strontium–90 activities. Some "spot check" determinations for polonium–210 have also been performed. Additional analysis for this radionuclide is required before any data can be reported.

These determinations have been added to provide a more definitive picture of the total radioactivity in Basin surface waters resulting from uranium industry operations and nuclear weapons–testing programs.

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Analytical methods

Water samples are composited and filtered through 0.45-micron membrane filters as soon as possible after the samples for the compositing period are received. After filtration they are acidified with 2 percent by volume of 12 *N* HCl.

Radium-226 is determined by an emanation method (*4*). Lead-210 is determined by an iodide-dithiozone extraction method (*5*). Uranium is determined by a fluorimetric method, using a sodium carbonate-potassium carbonate-sodium fluoride flux (*6*). Gross alpha and beta determinations are made on dried dissolved solids from the waters, using appropriate correction factors for self-absorption. Strontium-90 is isolated by coprecipitation with calcium and magnesium carbonate. It is adsorbed in an ion exchange column and the yttrium-90 which grows in is eluted and measured. Gross gamma determinations are done using a sodium iodide crystal as a detector and a scaler as the recording device.

Alpha-emitting thorium isotopes are determined by coprecipitation with ferric hydroxide and lanthanum fluoride followed by extraction with thenoyltrifluoroacetone, mounting, and alpha counting.

Results

A summary of all radium-226 and uranium determinations on Radium Monitoring Network samples is given in table 1. The figures given in the table represent all sampling results obtained since the inception of the first network stations in October and November 1961. Figure 2 presents a graphical summary of radium-226 results at each individual station and table 2 gives the uranium data. Table 3 presents the quarterly composite results for the gross alpha, gross beta, lead-210, thorium alpha, and strontium-90. These latter results cover the period July 1963 through June 1964. Results on all reported parameters are for the dissolved solids portion of the sample passing the 0.45 micron filter.

In keeping with the philosophy of minimum exposure (*2*), the majority of the uranium processing mills in the Colorado River Basin have successfully maintained negligible radioactivity contributions to Colorado River Basin waters through their efforts to provide proper treatment and containment of milling waste products. Even at those mills where significant contributions have occurred since 1960, only eight of the 1,410 composite samples analyzed for radium-226 have indicated concentrations

Table 1. Radium-226 and uranium in surface waters of the Colorado River Basin

Sampling station number and location	Radium-226			Uranium		
	Average (pg/liter)	Range (pg/liter)	No. of analyses	Average (ug/liter)	Range (ug/liter)	No. of analyses
Animas River:						
#11 above Durango, Colo	0.05	0.03-0.11	38	1.1	0.1-2.5	32
#12 Colorado-New Mexico State line	0.30	0.09-1.5	89	4.0	0.4-18	47
Colorado River:						
# 1 at Silt, Colo	0.21	0.04-0.39	43	3.0	0.1-4.4	29
# 4 at DeBeque, Colo	0.20	0.05-0.44	44	3.8	0.4-7.2	29
# 6 at Fruita, Colo	0.19	0.09-0.26	39	9.7	3.2-14	30
# 9 above Moab, Utah	0.27	0.10-0.50	73	10	3.6-17	59
#10 below Moab, Utah	0.43	0.18-7.2	66	12	3.7-22	55
#31 at Page, Ariz	0.24	0.16-0.31	22	8.8	6.5-13	22
#32 Lake Mead, Nev	0.32	0.21-0.40	24	8.5	5.6-11	24
#33 Lake Havasu, Calif	0.35	0.06-0.41	26	8.4	5.9-11	26
#30 at Yuma, Ariz	0.17	0.06-0.33	34	8.3	5.9-11	29
Dolores River:						
#21 at Bedrock, Colo	0.51	0.03-1.4	42	14	0.9-35	29
#36 at Gateway, Colo	1.2	0.04-3.2	81	13	0.1-51	58
Green River:						
#26 below Maybell, Colo	0.09	0.03-0.15	33	2.7	0.6-8.0	29
#29 below Green River, Utah	0.09	0.05-0.15	28	5.0	1.6-7.6	25
Tomichi Creek:						
#22 above Gunnison, Colo	0.02	0.01-0.04	7	NA	NA	NA
Gunnison River:						
#24 above Gunnison, Colo	0.05	0.01-0.08	39	1.2	0.0-2.6	29
#35 below Gunnison, Colo	0.04	0.01-0.09	42	2.2	0.6-4.3	29
# 5 at Grand Junction, Colo	0.10	0.01-0.30	38	11	0.7-19	29
San Juan River:						
#13 above Farmington, N. Mex	0.07	0.03-0.16	20	2.8	0.0-8.3	19
#14 below Farmington, N. Mex	0.10	0.04-0.21	30	3.6	0.9-9.0	29
#14S below Shiprock, N. Mex	0.10	0.04-0.26	95	14	2.0-93	91
#15 above Mexican Hat, Utah	0.14	0.04-0.66	42	7.8	2.6-23	29
#16 below Mexican Hat, Utah	0.14	0.01-0.84	113	9.8	0.8-35	95
San Miguel River:						
#17 above Naturita, Colo	0.04	0.00-0.19	57	1.2	0.0-3.9	29
#18 above Uravan, Colo	0.23	0.05-1.24	90	6.8	0.9-63	59
#20 below Uravan, Colo	1.0	0.06-5.6	154	31	0.0-150	126

NA indicates no analysis performed.

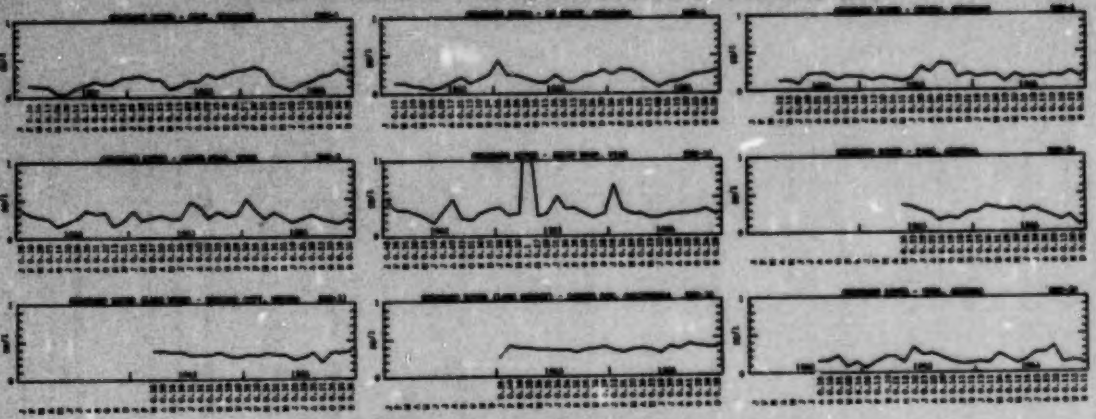

Figure 2. Dissolved radium-226 in Colorado River waters

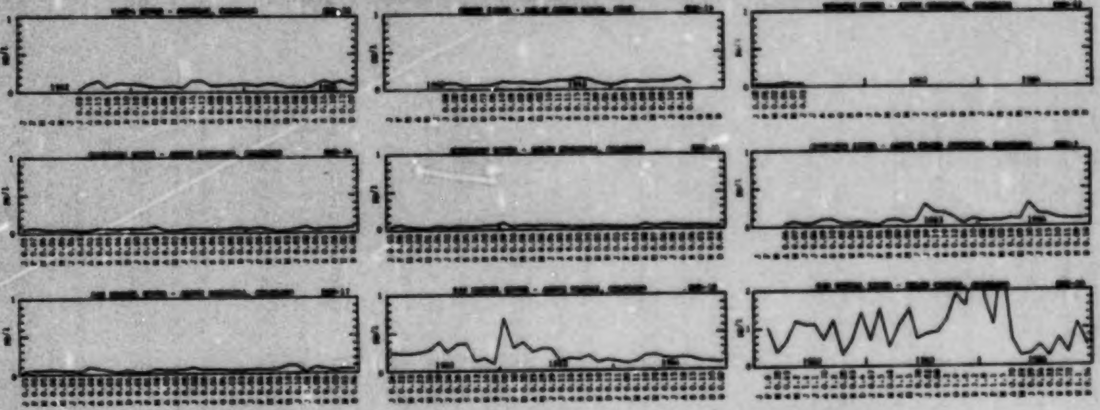

Figure 3. Dissolved radium-226 in Yampa, Green, Tomichi, Gunnison, and San Miguel River waters

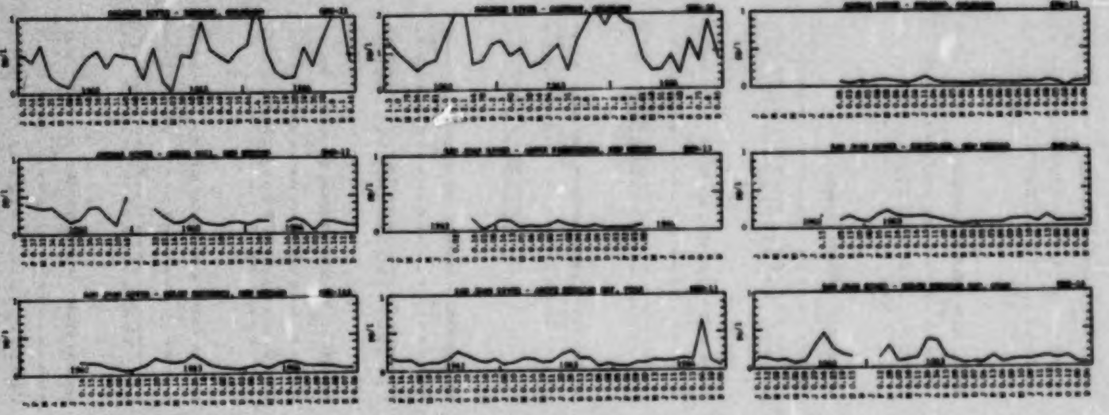

Figure 4. Dissolved radium-226 in Dolores, Animas, and San Juan River waters

Table 2. Dissolved uranium in Colorado River Basin surface waters

COLORADO RIVER - SILT, COLORADO — RRW-1

	1962	1963	1964
J		3.1	3.4
F		3.0	2.7
M		3.9	3.2
A		2.8	3.5
M		0.1	1.5
J		0.0	1.8
J		2.3	2.7
A		3.9	2.2
S		2.9	2.9
O	3.3	3.0	3.5
N	3.2	3.4	3.9
D	3.6	4.4	6.3

COLORADO RIVER - DE BEQUE, COLORADO — RRW-4

	1962	1963	1964
J		6.3	4.3
F		6.6	4.5
M		5.1	4.4
A		3.2	2.9
M		0.0	1.8
J		0.7	1.3
J		2.3	2.9
A		3.3	3.3
S		3.6	3.7
O	6.5	6.2	6.0
N	6.3	6.2	7.2
D	6.3	3.5	3.8

COLORADO RIVER - FRUITA, COLORADO — RRW-6

	1962	1963	1964
J		9.9	10
F		9.5	9.2
M		8.1	7.6
A		6.2	10
M		4.0	5.7
J		4.7	3.2
J		12	8.9
A		12	8.8
S		14	13
O	8.5	14	16
N	8.3	11	12
D	10	13	14

COLORADO RIVER - ABOVE MOAB, UTAH — RRW-9

	1962	1963	1964
J		11	12
F		11	11
M		12	13
A		8.5	9.7
M		8.6	7.6
J		4.7	5.6
J		14	7.8
A		17	12
S		18	9.6
O	9.3	16	16
N	10	11	15
D	11	15	16

COLORADO RIVER - BELOW MOAB, UTAH — RRW-10

	1962	1963	1964
J		16	12
F		13	13
M		16	13
A		10	9.7
M		9.2	5.6
J		5.4	3.7
J		12	6.5
A		17	8.6
S		16	16
O	9.0	16	18
N	12	12	17
D	13	10	16

COLORADO RIVER - PAGE, ARIZONA — RRW-31

	1962	1963	1964
J			8.4
F			10
M			7.5
A			11
M		13	9.1
J		11	9.2
J		9.2	11
A		7.4	10
S		7.1	6.9
O		7.9	6.5
N		8.5	7.8
D		8.6	7.8

COLORADO RIVER - BOULDER CITY, NEVADA — RRW-32

	1962	1963	1964
J			7.4
F			8.6
M		10	9.0
A		8.8	9.6
M		8.0	7.9
J		7.8	6.9
J		7.4	9.0
A		7.0	9.2
S		7.9	8.8
O		8.6	11
N		5.8	8.8
D		8.1	11

COLORADO RIVER - PARKER DAM, CALIFORNIA — RRW-33

	1962	1963	1964
J		9.9	7.7
F		11	8.7
M		11	7.9
A		9.9	8.1
M		8.2	8.8
J		8.1	7.2
J		8.9	7.9
A		6.6	8.1
S		7.2	8.4
O		6.2	8.6
N		5.9	8.9
D		7.4	8.5

COLORADO RIVER - YUMA, ARIZONA — RRW-30

	1962	1963	1964
J		9.3	7.1
F		11	7.1
M		8.8	9.0
A		9.2	8.2
M		9.6	7.9
J		9.2	7.5
J		7.2	8.8
A		7.9	8.1
S		7.0	9.2
O	9.6	6.7	9.2
N	8.3	5.9	8.8
D	8.0	7.1	[illegible]

YAMPA RIVER - DUNHAM, COLORADO — RRW-28

	1962	1963	1964
J		2.8	0.8
F		4.9	1.9
M		8.0	0.9
A		1.5	7.9
M		1.8	1.8
J		1.2	0.6
J		4.0	1.7
A		3.1	2.4
S		1.8	3.5
O	2.4	2.5	3.5
N	2.3	2.6	2.9
D	2.0	2.8	3.6

GREEN RIVER - BELOW GREEN RIVER, UTAH — RRW-29

	1962	1963	1964
J		6.0	5.0
F		5.1	5.0
M		7.6	6.1
A		7.3	3.9
M		3.2	6.3
J		1.6	3.6
J		2.6	3.3
A		4.8	3.3
S		5.5	5.5
O	6.0	6.1	5.2
N	7.3	7.4	
D	6.2	5.6	

TOMICHI CREEK - ABOVE GUNNISON, COLORADO — RRW-22

NO DATA

GUNNISON RIVER - ABOVE GUNNISON, COLORADO — RRW-24

	1962	1963	1964
J		2.6	1.3
F		1.2	1.3
M		0.5	0.7
A		0.9	1.5
M		0.9	1.5
J		0.6	0.6
J		1.0	1.0
A		0.0	1.4
S		0.6	1.2
O	1.3	1.1	1.7
N	1.2	0.1	1.3
D	1.9	2.5	1.9

GUNNISON RIVER - BELOW GUNNISON, COLORADO — RRW-25

	1962	1963	1964
J		3.2	2.7
F		3.2	2.9
M		2.0	1.8
A		0.9	2.9
M		0.4	2.2
J		1.0	1.0
J		0.6	1.9
A		0.7	1.6
S		1.5	2.0
O	3.0	1.6	2.4
N	2.3	1.3	4.3
D	2.6	3.6	4.3

GUNNISON RIVER - ABOVE GRAND JUNCTION, COLORADO — RRW-5

	1962	1963	1964
J		13	12
F		10	11
M		10	12
A		4.7	6.4
M		2.9	3.5
J		0.7	4.0
J		12	8.9
A		14	10
S		17	14
O	12	15	19
N	13	13	17
D	13	14	14

SAN MIGUEL RIVER - ABOVE NATURITA, COLORADO — RRW-17

	1962	1963	1964
J		1.1	1.2
F		1.3	1.0
M		2.1	0.1
A		0.1	1.5
M		0.0	0.9
J		0.3	0.0
J		2.3	1.0
A		0.8	1.2
S		1.6	2.7
O	1.2	3.9	2.3
N	1.0	0.6	2.4
D	0.9	2.0	2.2

SAN MIGUEL RIVER - ABOVE URAVAN, COLORADO — RRW-18

	1962	1963	1964
J		11	3.2
F		11	3.9
M		8.9	2.5
A		3.2	3.2
M		2.2	1.8
J		2.1	0.9
J		7.7	3.7
A		3.8	3.5
S		3.1	6.3
O	3.8	6.0	3.3
N	6.5	1.9	3.0
D	7.0	3.7	5.0

SAN MIGUEL RIVER - BELOW URAVAN, COLORADO — RRW-20

	1962	1963	1964
J		62	28
F		27	55
M		27	49
A		16	52
M		10	2.3
J		1.8	5.0
J		17	19
A		46	20
S		38	41
O	11	31	35
N	21	16	59
D	57	22	44

DOLORES RIVER - BEDROCK, COLORADO — RRW-21

	1962	1963	1964
J		8.9	13
F		7.4	16
M		9.8	17
A		2.9	6.8
M		0.9	2.6
J		6.3	2.0
J		11	11
A		31	8.5
S		[illegible]	21
O	11	28	29
N	12	35	30
D	11	14	12

DOLORES RIVER - GATEWAY, COLORADO — RRW-26

	1962	1963	1964
J		12	28
F		16	
M		1.9	31
A		9.3	36
M		4.3	6.8
J		3.1	4.0
J		15	13
A		23	9.2
S		29	33
O	11	16	31
N	3.0	22	30
D	3.3	35	33

ANIMAS RIVER - DURANGO, COLORADO — RRW-11

	1962	1963	1964
J		1.2	1.0
F		2.1	1.1
M		1.2	1.0
A		0.2	0.6
M		2.5	0.6
J		0.9	0.7
J		1.5	0.7
A		0.3	0.9
S		1.0	1.4
O	1.0	0.8	1.9
N	1.8	1.1	1.9
D	0.6	1.3	1.9

ANIMAS RIVER - CEDAR HILL, NEW MEXICO — RRW-12

	1962	1963	1964
J			2.4
F			2.5
M		6.9	2.5
A		2.0	
M		2.0	1.3
J		1.2	0.7
J		2.5	1.6
A		2.2	2.3
S		1.8	3.7
O	7.4	4.4	6.0
N	8.7	4.0	3.7
D	6.0	4.4	3.3

SAN JUAN RIVER - ABOVE FARMINGTON, NEW MEXICO — RRW-13

	1962	1963	1964
J		4.0	1.2
F		5.5	1.3
M		1.9	1.2
A		0.8	2.2
M		3.[illegible]	
J		1.9	
J		1.7	
A		4.5	
S		2.3	
O	8.3	1.1	
N	3.4	0.0	
D	4.3	2.6	

SAN JUAN RIVER - FRUITLAND, NEW MEXICO — RRW-14

	1962	1963	1964
J		6.6	2.5
F		7.7	3.0
M		9.0	2.0
A		1.9	2.4
M		3.2	2.1
J		2.8	0.9
J		2.7	1.6
A		4.2	2.3
S		2.0	3.5
O	5.1	2.9	3.2
N	7.0	2.2	4.0
D	6.[illegible]	3.6	4.0

SAN JUAN RIVER - BELOW SHIPROCK, NEW MEXICO — RRW-14B

	1962	1963	1964
J		12	15
F		16	3.6
M		16	2.7
A		2.3	11
M		11	30
J		7.5	6.9
J		22	6.5
A		13	5.4
S		3.6	11
O	8.3	18	18
N	11	16	16
D	13	14	14

SAN JUAN RIVER - ABOVE MEXICAN HAT, UTAH — RRW-15

	1962	1963	1964
J		13	5.3
F		8.9	6.2
M		11	5.9
A		5.7	7.0
M		5.9	5.9
J		5.7	2.6
J		11	3.0
A		12	3.8
S		6.3	9.3
O	8.7	7.4	23
N	9.9	4.5	8.8
D	9.8	6.5	7.8

SAN JUAN RIVER - BELOW MEXICAN HAT, UTAH — RRW-16

	1962	1963	1964
J		0.2	7.5
F		15	12
M		12	0.8
A		14	6.5
M		6.2	6.7
J		0.0	3.4
J		8.6	3.3
A		10	3.8
S		12	16
O	10	11	26
N	11	6.7	19
D	9.0	3.3	14

above the currently accepted yearly average limit of 3 pCi/liter for radium in drinking water (*7*). No network sampling station has exhibited an overall average above this limit and only two stations have sustained average radium-226 concentrations at or slightly above the 1 pg/liter suggested maximum desirable level for Colorado River Basin waters (*8*).

The quarterly gross alpha figures given in table 3 agree with the general range of monthly figures reported by the Public Health Service Water Pollution Surveillance System (WPSS) for their Colorado River Basin stations, while the gross beta results tend to range somewhat lower than the WPSS results.

The lead-210 and thorium alpha results are consistently low throughout the Basin, but concentrations in several sample composites collected immediately below uranium mill waste discharges were found to be higher than upstream levels. The highest thorium alpha level of 8.0 pCi/liter reported for the second quarter below Uravan, Colorado, may be erroneous in view of the lower levels obtained for the other three quarters.

Four of the five river sampling stations, which are subject to flow fluctuations and for which strontium-90 determinations were performed, tend to show higher-than-average strontium-90 levels during July-September 1963. Additionally, several slightly higher levels occurred in the April-June and July-September 1964 quarters, suggesting a seasonal variation related to runoff collection of fallout. The other two stations which are sampled for strontium-90 are in regulated flow "reaches" and are not immediately affected by runoff.

All gross gamma determinations on the quarterly composites were below 33 pCi/liter, the minimum detectable activity obtainable with the available equipment and sample characteristics.

Table 3. Gross alpha, gross beta, thorium alpha, lead-210, and strontium-90 in Colorado River Basin surface waters

Station number and location	Quarter[1] period	Gross alpha (pCi/liter)	Gross beta (pCi/liter)	Th-alpha (pCi/liter)	^{210}Pb (pCi/liter)	^{90}Sr (pCi/liter)
RMN 1 Colorado River at Silt, Colorado	1	2	10	NA	NA	NA
	2	2	18	NA	0.4	NA
	3	2	8	0.4	0.1	NA
	4	3	20	0.1	0.1	NA
RMN 4 Colorado River at DeBeque, Colorado	1	3	11	NA	NA	2.8
	2	3	22	NA	NA	0.9
	3	3	9	NA	NA	0.9
	4	1	23	NA	NA	1.8
RMN 6 Colorado River below Grand Junction, Colorado	1	7	41	0.1	0.1	NA
	2	5	11	0.0	0.3	NA
	3	7	22	0.5	0.1	NA
	4	2	14	0.1	0.0	NA
RMN 9 Colorado River above Moab, Utah	1	8	33	NA	NA	8.4
	2	12	20	NA	NA	1.6
	3	5	12	NA	NA	1.2
	4	2	16	NA	NA	2.2
RMN 10 Colorado River below Moab, Utah	1	9	21	0.1	0.0	NA
	2	4	8	0.2	0.1	NA
	3	6	16	0.0	0.1	NA
	4	3	14	0.0	0.0	NA
RMN 11 Animas River at Durango, Colorado	1	1	5	NA	NA	0.9
	2	1	5	NA	NA	0.7
	3	1	9	NA	NA	0.9
	4	1	8	NA	NA	1.5
RMN 14B San Juan River below Shiprock, New Mexico	1	12	16	0.0	0.1	NA
	2	7	14	0.1	0.0	NA
	3	3	9	0.0	0.0	NA
	4	8	14	0.2	0.0	NA
RMN 15 San Juan River above Mexican Hat, Utah	1	6	20	NA	NA	6.0
	2	4	14	NA	NA	3.3
	3	4	10	NA	NA	2.0
	4	3	14	NA	NA	2.9
RMN 16 San Juan River below Mexican Hat, Utah	1	6	20	0.4	0.2	NA
	2	5	12	0.3	0.1	NA
	3	4	[illegible]	0.3	0.2	NA
	4	4	10	0.3	0.3	NA
RMN 17 San Miguel River above Naturita, Colorado	1	[illegible]	7	0.1	0.0	NA
	2	[illegible]	7	0.1	0.0	NA
	3	[illegible]	7	0.1	0.1	NA
	4	[illegible]	[illegible]	0.0	0.0	NA
RMN 20 San Miguel River below Uravan, Colorado	1	12	22	1.1	0.6	NA
	2	10	28	8.0	0.4	NA
	3	[illegible]	28	0.8	0.3	NA
	4	12	28	1.0	0.1	NA
RMN 29 Green River below Green River, Utah	1	2	20	NA	NA	9.6
	2	2	14	NA	NA	3.3
	3	1	16	NA	NA	2.5
	4	3	12	NA	NA	3.3
RMN 22 Colorado River (Lake Mead) at Boulder City, Nevada	1	2	5	NA	NA	1.1
	2	2	10	NA	NA	1.2
	3	4	4	NA	NA	1.2
	4	5	9	NA	NA	1.4
RMN 23 Colorado River at Parker Dam, California	1	5	9	0.0	0.2	NA
	2	5	22	0.0	0.2	NA
	3	4	9	0.1	0.1	NA
	4	4	11	0.2	0.0	NA
RMN 30 Colorado River at Yuma, Arizona	1	6	8	NA	NA	1.2
	2	4	10	NA	NA	1.5
	3	2	11	NA	NA	1.3
	4	4	10	NA	NA	1.5

[1] Quarter period
1 July—September 1963
2 October—December 1963
3 January—March 1964
4 April—June 1964
NA indicates no analysis performed.

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(*1*) WRUBLE, D. T., S. D. SHEARER, D. E. RUSHING, and C. E. SPONAGLE. Radioactivity in waters and sediments of the Colorado river basin, 1950-1963. Rad Health Data 5:557-567 (November 1964).

(*2*) NATIONAL COMMITTEE ON RADIATION PROTECTION. Maximum permissible body burdens and exposure. Recommendations of the National Committee on Radiation Protection, National Bureau of Standards Handbook 69. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (June 1959). Price 35 cents.

(*3*) TSIVOGLOU, E. C., and R. L. O'CONNELL. Waste guide for the uranium milling industry, TR W62-12. Department of Health, Education, and Welfare, Division of Water Supply and Pollution Control, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

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(*7*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. PHS Publication No. 956. Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402. Price 30 cents.

(*8*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Transcript, Third Session Conference of Interstate Waters of the Colorado River and its Tributaries. U.S. Department of Health, Education, and Welfare, Region VIII, Denver, Colorado (May 1962).

RADIOACTIVITY IN FLORIDA WATERS, 1964[1]

Division of Radiological and Occupational Health, Florida State Board of Health

The Florida State Board of Health samples raw surface water from locations in 13 hydrological subbasins. In nine of these subbasins, raw ground water is also sampled. The samples are collected on a variable frequency and analyzed for gross alpha and beta radioactivity.

Figure 1 shows the locations of the surface water subbasins from which samples are obtained. Average gross alpha and gross beta radioactivity levels in raw surface waters during 1964 are presented in table 1, while table 2 gives the radioactivity levels in ground waters.

The average gross beta radioactivity in water supplies is well below the standard for gross beta radioactivity in drinking water (1,000 pCi/liter), as is average gross alpha radioactivity when compared to its standard for drinking water (3 pCi/liter when radium is present) (*1*).

In addition to the sampling being done by the Florida State Board of Health, the Sanitary Engineering Research Laboratory, University of Florida, samples raw surface water and water supplies in Alachua County and analyzes the samples for gross alpha and gross beta radioactivity. Samples are taken monthly except at Gainesville, where raw water is sampled daily. These data are summarized in table 1 as quarterly and yearly averages.

The yearly average beta activity in surface waters was more than double that in ground waters. This additional beta activity in surface waters is attributed to fallout. The alpha activity, which is attributed to natural activity of minerals, is very nearly the same for ground and surface water. The presence of gross beta activity due to fallout is clearly evident when comparing gross beta radioactivity

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[1] Data taken from "Report of Florida Radiological Data, Environmental Monitoring Programs, 1964," Florida State Board of Health, Bureau of Preventable Diseases, Division of Radiological and Occupational Health, Jacksonville, Florida.

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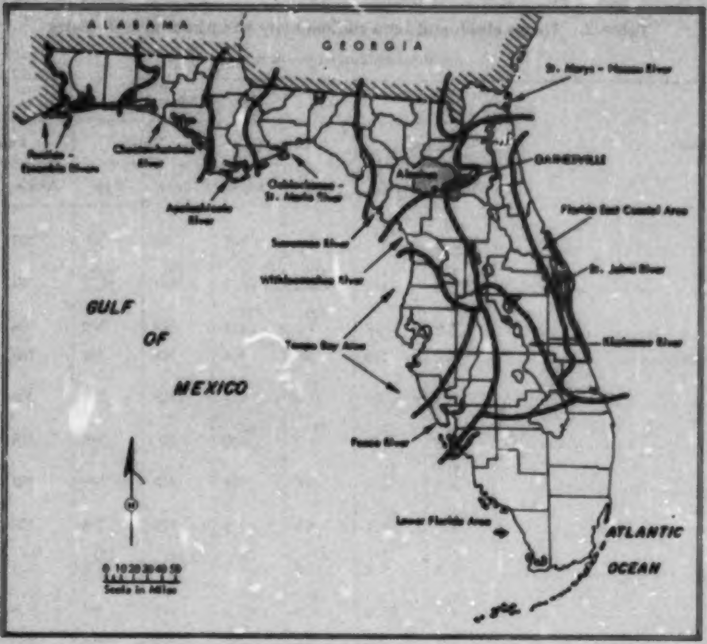
ALABAMA
GEORGIA
St. Marys - Nassau River
GAINESVILLE
Florida East Coastal Area
St. Johns River
Kissimmee River
Perdido - Escambia River
Choctawhatchee River
Apalachicola River
Ochlockonee - St. Marks River
Suwannee River
Withlacoochee River
Tampa Bay Area
Peace River
Lower Florida Area
GULF OF MEXICO
ATLANTIC OCEAN
0 10 20 30 40 50
Scale in Miles

Figure 1. Hydrological surface subbasins in Florida

Table 1. Gross alpha and beta radioactivity in raw surface water, 1965

(Concentrations in pCi/liter)

Subbasin	Quarter, 1964								Yearly average	
	First		Second		Third		Fourth			
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
St. Marys—Nassau River	(1) 0.2	(1) 61.5	NS	NS	NS	NS	(2) 0.2	(2) 24.0	(3) 0.2	(3) 36.5
St. Johns River	(25) 0.3	(25) 60.1	(17) 0.2	(17) 55.2	(17) 0.6	(17) 79.2	(15) 0.4	(15) 71.1	(74) 0.4	(74) 65.6
Suwannee River	(2) 0.1	(2) 74.2	(10) 0.4	(10) 32.2	NS	NS	NS	NS	(12) 0.4	(12) 39.2
Ochlockonee—St. Marys River	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Withlacoochee River	NS	NS	(7) 0.1	(7) 32.1	NS	NS	(3) 0.2	(3) 38.2	(10) 0.1	(10) 33.9
Tampa Bay Area	(2) 0.0	(2) 38.5	(3) 0.4	(3) 18.0	NS	NS	NS	NS	(5) 0.2	(5) 26.2
Peace River	(3) 0.7	(3) 57.9	(2) 0.6	(2) 59.5	NS	NS	NS	NS	(5) 0.7	(5) 58.5
Kissimmee River	(5) 0.4	(5) 55.8	(2) 0.2	(2) 42.4	(1) 0.4	(1) 46.2	(2) 0.4	(2) 31.2	(10) 0.4	(10) 47.2
Florida East Coastal Area	(21) 0.3	(21) 58.9	(7) 0.3	(7) 78.2	(13) 0.4	(13) 139.0	NS	NS	(41) 0.3	(41) 87.6
Lower Florida Area	(5) 0.4	(5) 50.9	(2) 0.4	(2) 60.7	NS	NS	(2) 0.2	(2) 41.7	(9) 0.4	(9) 51.0
Apalachicola River	(4) 0.3	(4) 20.0	NS	NS	NS	NS	(1) 0.4	(1) 16.6	(5) 0.3	(5) 19.3
Choctawhatchee	(6) 0.3	(6) 17.2	NS	NS	NS	NS	(2) 0.1	(2) 8.0	(8) 0.3	(8) 14.9
Perdido—Escambia Rivers	(4) 0.3	(4) 32.3	NS	NS	NS	NS	(2) 0.7	(2) 11.3	(6) 0.4	(6) 25.3
Total samples Average	(78) 0.3	(78) 52.0	(50) 0.3	(50) 48.2	(31) 0.5	(31) 103.2	(29) 0.3	(29) 49.3	(188) 0.3	(188) 59.0

Note: Number in parentheses indicates number of samples.
NS indicates no sample collected.

Table 2. Gross alpha and beta radioactivity in untreated well water

(Concentrations in pCi/liter)

Subbasin	Quarter, 1964								Yearly average	
	First		Second		Third		Fourth			
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
St. Marys-Nassau River	(1) 0.2	(1) 5.5	NS	NS	NS	NS	NS	NS	(1) 0.2	(1) 5.5
St. Johns River	(4) 0.2	(4) 34.1	(2) 0.3	(2) 32.7	(3) 0.1	(3) 16.3	NS	NS	(9) 0.2	(9) 27.9
Suwannee River	NS	NS	(2) 0.2	(2) 4.5	NS	NS	NS	NS	(2) 0.2	(2) 4.5
Ochlockonee—St. Marys River	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Withlacoochee River	NS	NS	(2) 0.6	(2) 3.5	NS	NS	NS	NS	(2) 0.6	(2) 3.5
Tampa Bay Area	NS	NS	(1) 0.3	(1) 5.0	NS	NS	NS	NS	(1) 0.3	(1) 5.0
Peace River	(1) 0.6	(1) 4.9	NS	NS	NS	NS	NS	NS	(1) 0.6	(1) 4.9
Kissimmee River	(2) 0.3	(2) 7.1	NS	NS	NS	NS	NS	NS	(2) 0.3	(2) 7.1
Florida East Coastal Area	(7) 0.2	(7) 8.8	(2) 0.2	(2) 43.3	(4) 0.3	(4) 8.6	(3) 0.2	(3) 12.6	(16) 0.2	(16) 13.8
Lower Florida Area	(5) 0.8	(5) 58.8	(4) 0.1	(4) 50.9	NS	NS	(1) 0.8	(1) 5.5	(10) 0.5	(10) 50.3
Apalachicola River	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Choctawhatchee River	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Perdido—Escambia Rivers	(1) 0.8	(1) 10.3	NS	NS	NS	NS	NS	NS	(1) 0.8	(1) 10.3
Total samples Average	(21) 0.4	(21) 26.1	(13) 0.3	(13) 28.9	(7) 0.2	(7) 11.9	(4) 0.3	(4) 11.0	(45) 0.3	(45) 23.4

Note: Number in parentheses indicates number of samples.
NS indicates no sample collected.

in raw surface water and raw well water. However, no obvious trend in gross beta radioactivity levels as a function of fallout was indicated by the data obtained.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Public Health Service drinking water standards, revised 1962. Publication No. 956. U.S. Government Printing Office, Washington, D.C. 20402 (1963). Price 30 cents.

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RADIOACTIVITY IN NORTH CAROLINA SURFACE, GROUND, AND CISTERN WATERS,[1] JANUARY-DECEMBER 1964

Sanitary Engineering Division and Laboratory Division
North Carolina State Board of Health

In recognition of the growing use of radioactive materials in the State of North Carolina, the Sanitary Engineering Division and the State Laboratory of Hygiene of the State Board of Health, with the cooperation of municipalities, began in June 1958 a program of measurement of radioactivity in surface waters used as public water supplies. Some 147 sampling points were established to sample raw surface water. In July 1962, the program was expanded to include the sampling of cistern water from Ocracoke Island. Then, in January 1963, other types of environmental samples were also collected (*1*), two of which were treated water from surface water supplies and ground water from wells used as municipal water supplies.

All waters contain traces of radioactivity originating from naturally radioactive minerals dissolved from rock strata or from radioactive particulate material or gases in the atmosphere. Common among these materials are trace elements of potassium-40, radium, thorium, and uranium. Such trace elements are dissolved by water both on its way to and flowing in the watercourses. Precipitation is the major mechanism by which particulate matter or radioactive gases, such as thoron and radon, are removed from the atmosphere. The combined radioactivity of these materials constitutes what is known as "background radioactivity" of the water. The total activity would include both background radioactivity and contributions from fallout and other man-made sources.

A knowledge of the concentration of the background radioactivity as well as the total activity is an important factor in the appraisal of water quality, since standards pertaining to radiation exposure or concentration within drinking water are expressed in terms of "additions to the natural background" (*2*). Surface water data for 1958 through 1961 are considered as background radioactivity and have previously been published in *Radiological Health Data* (*3*).

Laboratory procedure

Total solids content is determined for each sample so that proper sample proportions may be used in analysis. The calculated amount of a sample is concentrated to a few milliliters on a steam bath. The residue is transferred to a stainless-steel planchet and evaporated to dryness under an infrared light. After further drying for 1 hour at 103° C., the sample is cooled in a desiccator and is then counted.

Alpha-plus-beta counting is done in a gas-flow internal proportional counter calibrated with a radium D+E source. Taking instrument background (17 counts per minute) into consideration, each sample is counted for a preset count and the results are reported in terms of pCi/liter.

Results

Table 1 gives the average gross (alpha-plus-beta) radioactivity in raw surface water as well as the maximum and minimum values recorded during 1964. The first column consists of code numbers which indicate the geographical positions of the sampling stations, as shown in figure 1.

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[1] Summarized from "Background Radioactivity in Surface Water Supplies of North Carolina, 1958–1962" and "Environmental Surveillance, 1964."

Table 1. Gross radioactivity found in surface waters used as sources of public water supplies in North Carolina, 1964

(Radioactivity concentrations in pCi/liter)

Code	Location	Source of water supply	Raw Water				Treated Water			
			No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
1	Alamance	Big Alamance Creek	1	12.2			0			
2	Albemarle	Yadkin River	11	9.3	16.4	6.8	7	5.5	9.6	3.2
3	Andrews	Beaver Creek	2	3.7	3.9	3.6	0			
3a	Apex		2	10.6	25.2	13.1	0			
4	Asheboro	Back Creek	3	15.7	20.6	12.0	1	7.5		
5	Asheville	Bee Tree Creek	11	4.5	10.8	2.0	7	5.7	12.3	2.4
6	Badin	Yadkin River	2	11.8	15.1	8.5	0			
7	Belmont	Catawba River	4	7.1	17.4	1.0	0			
7a	Bessemer City		1	7.4			0			
8	Biscoe	Little River	4	30.2	48.6	6.7	0			
9	Blowing Rock	Brickhouse Creek	3	8.8	14.0	3.7	0			
9a	Boone		2	4.0	4.1	3.9	0			
9b	Brevard		2	3.0	3.6	2.4	0			
10	Bryson City	Lands Creek	1	3.3			0			
10a	Burgaw		2	23.4	25.8	21.7	0			
11	Burlington	Stony Creek	12	14.5	28.7	6.0	7	9.9	17.2	6.3
11a	Candor		3	15.9	25.6	5.5	0			
12	Canton	Pigeon River; Ruff Creek	2	3.1	4.2	2.1	0			
13	Carthage	Spring	2	8.1	8.8	7.5	0			
14	Chapel Hill	Price Creek	2	12.4	13.0	11.9	0			
15	Charlotte	Catawba River	11	8.6	16.6	5.1	8	5.7	9.6	2.3
16	Cliffside	Second Broad River	3	7.4	11.3	5.3	0			
17	Clinton	Black River	2	10.2	13.1	7.3	0			
18	Concord	Cold Water Creek & Lumby Creek	10	17.9	36.2	11.6	8	9.0	13.8	3.8
19	Cooleemee	South Fork Yadkin	2	7.7	8.3	7.3	0			
20	Cramerton	South Fork Catawba River	10	7.3	13.9	3.4	8	6.6	16.2	3.2
21	Creedmoor	Ledge Creek	2	14.9	16.5	13.3	0			
22	Cullowhee	Long Branch; Flat Creek	2	1.9	2.3	1.4	0			
23	Davidson	Cathy's Creek	2	8.0	10.5	5.7	0			
24	Denton	Lick Branch	2	15.1	19.5	10.0	0			
25	Dunn	Cape Fear River	3	15.7	22.9	11.2	0			
26	Durham	Flat River	11	14.8	21.1	9.7	8	8.3	17.1	2.2
27	Elizabeth City	Pasquotank River	0				1	10.0		
29	Elkin	Big Elkin Creek	2	5.8	9.0	2.6	0			
30	Fayetteville	Cape Fear River	11	18.4	38.0	5.9	8	9.3	18.0	3.3
31	Forest City	Second Broad River	2	7.1	9.0	5.2	0			
32	Fontana Dam	Little Tennessee River	1	5.0			0			
33	Franklinton	Kearney's Creek	1	6.2			0			
34	Gastonia	Long Creek; Catawba River	11	8.0	15.7	4.6	7	6.3	8.3	5.2
35	Goldsboro	Little River; Neuse River	2	18.1	20.2	16.1	1	7.4		
36	Graham	Back Creek	3	26.9	64.7	5.3	0			
37	Granite Falls	Catawba River	1	3.9			0			
38	Greensboro	Reedy Fork Creek	11	13.6	27.7	10.2	8	9.2	17.3	2.2
39	Greenville	Tar River	11	14.8	20.3	7.1	7	9.6	24.4	4.0
40	Hamlet	Marks Creek	1	7.0			0			
41	Henderson	Sandy Creek	0				0			
42	Hendersonville	North Fork Mills River and Bradley Creek	1	0.5			0			
43	Hertford	Perquimans River	0				0			
44	Hickory	Catawba River	10	7.8	16.2	4.2	8	6.7	15.2	4.4
45	High Point	Deep River	10	15.3	22.9	9.4	7	9.3	20.0	8.4
46	Hillsboro	Eno River	2	5.4	8.5	2.6	0			
47	Jamestown	Deep River	0				0			
48	Kannapolis	Buffalo Creek	12	15.2	33.4	8.5	7	8.7	11.6	3.8
49	Kernersville	Belew's Creek	1	9.0			0			
50	Kings Mountain	Kings Creek	1	4.6			0			
51	Landis	Grant's Creek	1	10.6			0			
52	Laurinburg	Jordan Creek	11	9.2	17.5	3.3	7	7.4	12.0	3.3
53	Leaksville	Dan River	3	5.4	7.8	4.3	0			
54	Lenoir	Zacks Fork Creek & Catawba River	3	9.8	16.9	4.6	0			
55	Lexington	Abbott's Creek	3	25.8	53.3	12.2	0			
56	Lillington	Cape Fear River	1	11.0			0			
57	Lincolnton	Walker Branch	2	6.3	7.8	4.9	0			
58	Louisburg	Tar River	1	3.5			0			
59	Lumberton	Lumber River	10	16.5	14.3	6.2	7	9.1	14.3	6.2
60	Marion	Mackey's Creek; Buck Creek	1	2.6			0			
60a	Mars Hill		1	1.8			0			
60b	Marshall		1	3.0			0			
61	Mayodan	Mayo River	1	17.4			0			
62	Mebane	Mills Creek	1	7.1			0			
63	Mocksville	Bear Creek	1	5.4			0			
64	Monroe	Richardson Creek	2	23.5	28.7	17.5	0			
65	Mooresville	Byers Creek; Catawba River	3	18.7	28.3	9.4	0			
66	Morganton	Henry River	3	2.6	3.1	2.2	0			
67	Mount Airy	Lovell's Creek	3	5.2	7.4	3.7	0			
68	Mount Gilead	Pee Dee River	3	12.7	17.2	9.7	0			
69	Mount Holly	Catawba River	10	9.5	16.7	3.4	6	7.3	11.5	5.5
70	Mount Pleasant	Dutch Buffalo Creek	1	13.7			0			

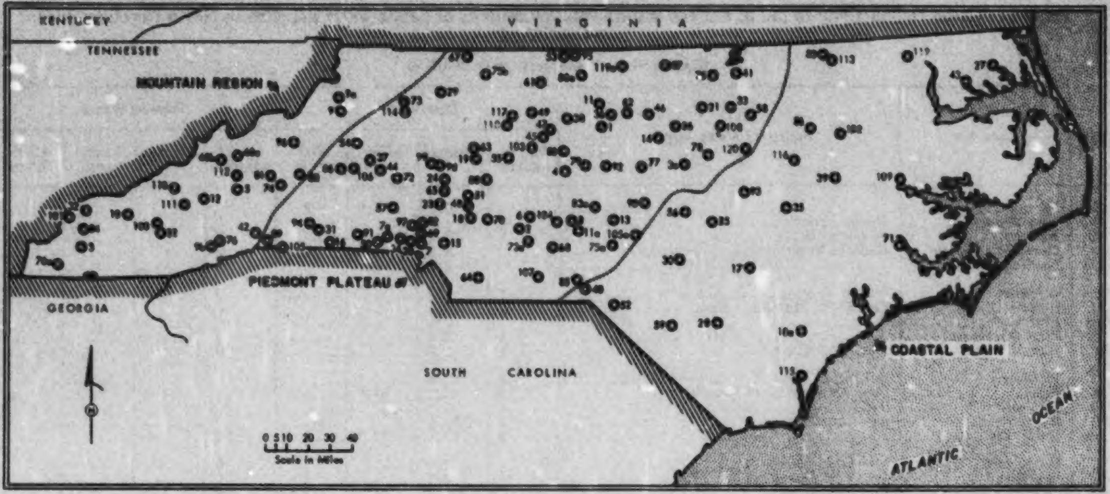
Table 1. Gross radioactivity found in surface waters used as sources of public water supplies in North Carolina, 1964 —Continued

(Radioactivity concentrations in pCi/liter)

Code	Location	Source of water supply	Raw Water				Treated Water			
			No. of samples	Average	Maximum	Minimum	No. of samples	Average	Maximum	Minimum
70a	Murphy		3	5.3	8.9	2.4	0			
71	New Bern	Neuse River	0				0			
72	Newton	Jacobs Fork	1	18.5			0			
73	North Wilkesboro	Reddies River	5	8.3	16.4	2.3	0			
73a	Norwood		1	7.1			0			
74	Old Fort	Jarrett Creek	1	9.5			0			
75	Oxford	Tar River; Hatcher's Run	1	23.1			0			
75a	Pinehurst		1	3.1			0			
75b	Pilot Mountain		1	12.4			0			
76	Pisgah Forest	Davidson River	1	3.5			0			
77	Pittsboro	Robinson Creek	1	27.6			0			
78	Raleigh	Lake Raleigh; Lake Wheeler	12	16.2	33.0	5.5	7	11.4	26.8	6.7
79	Ramseur	Sandy Creek	1	35.8			0			
80	Randleman	Pole Cat Creek	1	25.4			0			
80a	Reidsville		3	10.2	12.3	8.5	0			
81	Ridgecrest	Mountain Stream	1	2.9			0			
82	Riverbend	Catawba River	1	8.1			0			
83	Roanoke Rapids	Roanoke River	3	13.2	21.7	7.0	0			
83a	Robbins		1	20.7			0			
84	Robbinsville	Rock & Burgin's Creek	1	9.7			0			
85	Rockingham	Falling Creek	2	9.4	12.7	6.2	0			
86	Rocky Mount	Tar River	10	13.1	22.3	7.0	7	7.1	9.5	3.6
87	Roxboro	Lake Isaac Walton; Storey's Creek	1	16.4			0			
88	Salisbury	Yadkin River	10	13.8	49.8	5.2	7	7.0	10.5	3.1
89	Saluda	Paces Creek	0				0			
90	Sanford	Lick Creek; Potterage Creek	2	12.5	13.9	11.4	0			
91	Shelby	First Broad River	4	4.7	8.6	2.6	0			
92	Siler City	Rocky River	3	28.1	44.6	15.6	0			
93	Smithfield	Neuse River	10	20.5	36.1	7.2	8	13.4	44.9	1.9
93a	Southern Pines		1	18.9			0			
94	Spindale-Rutherfordton	Hollands Creek; Cathy's Creek	0				0			
95	Spray	Smith River	11	7.5	14.3	3.9	7	7.8	21.0	3.8
96	Spruce Pine	Beaver Creek	1	1.8			0			
97	Stanley	Hoyle's Creek	1	4.5			0			
98	Statesville	Fourth Creek	2	4.5	7.0	2.2	0			
99	Statesville	South Yadkin River	2	8.2	8.9	7.7	0			
100	Sylva	Dill's Creek	3	1.8	2.3	1.3	0			
101	Tapoco	Yellow Hammer Creek	1	2.0			0			
102	Tarboro	Tar River	3	15.9	19.2	11.8	0			
103	Thomasville	Abbott's Creek	3	11.7	23.2	1.9	0			
104	Troy	Denson Creek; Downing Creek	1	6.0			0			
105	Tryon	Falls Creek; Vaughn's Creek	1	3.9			0			
105a	Vass		1	13.9			0			
106	Valdese	Micol Creek; Hoyle Creek; Catawba River	2	9.7	12.3	7.4	0			
107	Wadesboro	Jones Creek	1	32.9			0			
108	Wake Forest	Smith's Creek	0				1	6.5		
109	Washington	Tranters Creek	1	31.6			0			
110	Waterville	Big Creek	1	2.2			0			
111	Waynesville	Cherry Cive & Shiney Creek	1	2.1			0			
112	Weaverville	Wagner Branch & Ox Creek	1	2.9			0			
113	Weldon	Roanoke River	1	12.2			0			
114	Wilkesboro	Cub Creek	1	4.3			0			
115	Wilmington	Cape Fear River	11	19.3	48.7	7.6	7	7.9	15.0	1.5
116	Wilson	Contentney Creek	0				0			
117	Winston-Salem	Salem Creek	4	10.4	15.2	5.8	5	5.7	7.4	0.9
118	Winston-Salem	Yadkin River	7	7.8	18.8	3.7	2	3.4	4.0	2.8
119	Winton	Chowan River	1	18.9			0			
119a	Yancyville		11	10.7			0			
120	Zebulon	Little River	3	8.8	10.5	7.3	0			

After purification of these surface waters, the finished water is distributed for domestic and industrial uses. Finished water from some of these supplies has been sampled for gross radioactivity. Table 1 gives the average, maximum, and minimum radioactivity in finished water from these supplies during 1964.

On some of the islands situated along the eastern seaboard of North Carolina (figure 2), and also at some private residences in Durham County, drinking water is obtained from small cistern water supplies. The cistern supplies are characteristically constructed with roof prewash valves which permit the diversion of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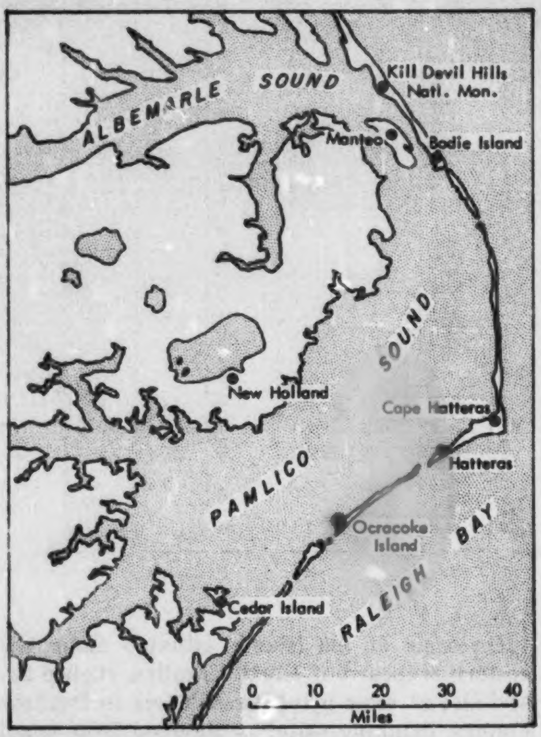
SOUTH CAROLINA
COASTAL PLAIN
ATLANTIC
OCEAN
0 5 10 20 30 40
Scale in Miles

Figure 1. North Carolina surface water sampling stations with code numbers

the first runoff and then allow the balance of the rainwater to pass into the cistern. A 1-liter sample is usually collected monthly and analyzed for gross radioactivity. Table 2 presents the results for five cistern water supplies on Ocracoke Island and in Durham County, from April through December 1964.


ALBEMARLE
SOUND
Kill Devil Hills
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New Holland
Cape Hatteras
Hatteras
PAMLICO
Ocracoke
Island
BAY
RALEIGH
Cedar Island
0 10 20 30 40
Miles

Figure 2. Eastern North Carolina, showing location of Ocracoke Island

Table 2. Gross radioactivity in cistern water in North Carolina, 1964

Location	Radioactivity concentrations, pCi/liter			
	Number of samples	Average	Maximum	Minimum
Ocracoke Island:				
Marina	7	67.2	143.1	17.5
Coast Guard Station	8	70.5	127.4	21.8
Residence A	1	80.1	80.1	80.1
Durham County:				
Residence B	6	67.4	85.7	27.9
Residence C	2	118.6	118.8	118.3

Discussion and interpretation of data

All results may be interpreted on the basis of the Public Health Service Drinking Water Standards (*4*), which state that in the absence of strontium-90 and alpha emitters, a water supply is acceptable if the gross beta activity does not exceed 1,000 picocuries per liter of water. This value relates to average intake from water over a long period of time and not from transient conditions.

The results for 1964 for ground water, raw surface water, finished water, and cistern water has been summarized in table 3, by region of the State (figure 1).

Table 3. Summary of results of gross radioactivity in water supplies in North Carolina, 1964

Type of water and region	No. of samples	Average	Maximum	Minimum
Ground water:				
Mountain region	10	2.5	5.2	0.7
Piedmont region	43	2.9	53.2	1.3
Coastal region	75	6.2	20.7	1.5
Raw surface water:				
Mountain region	54	4.4	13.9	1.3
Piedmont region	313	12.1	64.7	1.0
Coastal region	70	15.6	38.0	3.2
Finished water from surface supplies:				
Mountain region	7	5.7	12.3	2.4
Piedmont region	128	8.0	26.7	1.8
Coastal region	45	8.4	24.4	3.2
Cistern water:				
Ocracoke Island	17	69.6	143.1	17.5
Durham County	8	80.2	118.8	27.9

It is apparent that the coastal region has somewhat greater radioactivity in its ground water than the Piedmont and mountain regions, as indicated by averages of 6.2, 2.9, and 2.5 pCi/liter, respectively. These activities would be considered as background since the radioactivity present in the water is imparted to the ground waters from the dissolution of geological formations of granite, gneiss, and other bedrock. Radioactivity so imparted would be the combined contribution of such elements as natural uranium, thorium, radium, potassium and other long-lived materials occurring in nature.

It can be noted that the mountain surface waters contain less radioactive material (4.4 pCi/liter) than those in the Piedmont (12.1 pCi/liter) and coastal regions (15.6 pCi/liter). This is to be expected, since the surface waters in the mountains have fewer dissolved solids. As these waters flow toward the ocean their dissolved solid content increases, paralleled by increases in their natural as well as their fallout radioactivity concentrations.

The mountain region had an average of 5.7 pCi/liter in finished water, while the Piedmont and coastal regions reported averages of 8.0 and 8.4 pCi/liter, respectively. In order to directly compare the results for raw water and finished water, one should refer to the data for individual samples of raw and finished water collected at the same time (*5*). It appears that finished water had, on the average, lower concentrations than raw water.

Radioactivity in the raw water decreased from a 1963 average of 17.1 pCi/liter to the 1964 average of 11.8 pCi/liter, or approximately by one-third. Finished water levels of activity decreased from a 1963 activity of 9.7 pCi/liter to the 1964 level of 8.0 pCi/liter. This indicates a removal of radioactivity for 1964 of 33 percent compared to a 1963 value of 47 percent.

It is readily apparent that during 1964, cistern water contained more radioactivity than any of the other types of public water supplies sampled. The average values were 69.6 pCi/liter on Ocracoke Island and 80.2 pCi/liter in Durham County. These values more closely parallel the values observed in precipitation during 1964 than the values for ground and surface water.

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Previous coverage in *Radiological Health Data:*

Period	*Issue*
June–August 1962 (cistern water)	*February 1963*
June 1958–December 1961	*May 1963*
November 1961–December 1963	*September 1964*

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RADIONUCLIDE ANALYSIS OF COAST GUARD WATER SUPPLIES JANUARY–DECEMBER 1964

U.S. Coast Guard[1] *and Division of Radiological Health*[2]

Beginning in October 1961, 1-gallon samples of water have been obtained from seven Coast Guard Loran Stations in Alaska (figure 1).

The prime source of potable water at the Adak Loran Station is Alpine Lake which is at an elevation of 1,000 feet. The lake is occasionally frozen over with little snow cover each year from December through April. Water is delivered from the lake as needed through a 2-mile pipe line to three 25,000-gallon concrete reservoirs. All water is chlorinated at the station before use.

The Attu Loran Station's prime source of potable water is Alout Creek Dam and reservoir. This water source is usually frozen over from November through April, with a frequent snow cover of 1 to 3 feet. A 1-mile pipe line feeds water by gravity to three 25,000-gallon concrete reservoirs at the station. The water is chlorinated before use.

The Biorka Loran Station's water comes from a lake that is often frozen over lightly during January to March. The water is fed by gravity through a 1-mile long insulated pipe to a pump house. From there, it is pumped another mile to a 25,000-gallon steel storage tank from which it is fed by gravity one-half mile to the station, filtered, and chlorinated.

The source of water for the Cape Sarichef Loran Station is a small dammed creek and reservoir. The reservoir is usually frozen over from December through April, with 1 to 3 feet of snow cover during that period. The water is pumped 1½ miles from the dam to a 25,000-gallon steel storage tank above ground, from which the water is fed by gravity to the station, filtered, and chlorinated.

The Sitkinak Loran Station obtains its water from a natural lake which is normally frozen over from December through April, with 3 to 12 inches of snow cover during that period.

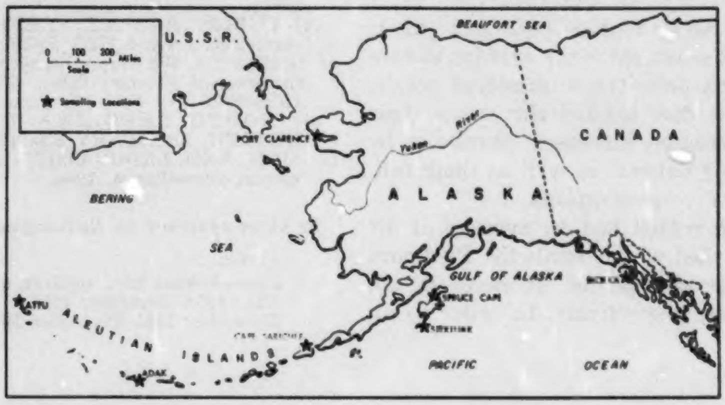

Figure 1. Coast Guard Loran Station water sampling locations

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[1] U.S. Department of the Treasury
[2] U.S. Public Health Service

The water is pumped from the lake through a 1,500-foot line to three 25,000-gallon concrete reservoirs at the station. The water is filtered and chlorinated as used.

Port Clarence Loran Station's source of water is two shallow, flatland lakes, which freeze solid to their depth of 1½ to 3 feet from November through May. A variable snow cover of 1 to 5 feet is normal during this period. The water is pumped beneath the ice and seasonal frost to the station's concrete cisterns of 225,000-gallon capacity. Normally the entire capacity of the station's tanks is topped off prior to December 1 and only a small amount of water is pumped from the lake area after that date, depending on the thickness of snow, ice, and frost cover during the winter months. At the time of the first thaw, usually in May, the station tanks are again filled and kept filled until the following winter freeze. All water is filtered and chlorinated before use.

A natural hillside lake is Spruce Cape Loran Station's source of water. The lake is generally ice-free throughout the entire winter season with only light snowfall and general slush. The water is pumped one-half mile from the lake to a 25,000-gallon wood-stave cistern from which it is fed by gravity to the station, filtered, and chlorinated.

Water samples are analyzed for gross alpha, gross beta, barium-lanthanum–140, cesium–137, iodine–131, ruthenium–103 — ruthenium–106, and zirconium-niobium–95. The radionuclide analyses are performed by gamma spectrometry. All analyses are performed by the Southwestern Radiological Health Laboratory, Las Vegas, Nevada. The results of the gross alpha and beta analyses are reported in table 1. Values for specific radionuclide content are not reported, since in all cases they were below the respective minimum detectable levels (cesium–137, 5 pCi/liter; all others, 10 pCi/liter).

Table 1. Radioactivity in water samples from U.S. Coast Guard Loran Stations, January 1964–December 1964

(Concentrations in pCi/liter)

Alaskan location	Collection date, 1964	Gross alpha	Gross beta
Adak	no sample		
Attu Island	January 11	<1.1	38
	February 7	<0.1	2
	April 3	<0.1	50
	May 1	<0.1	14
	June 9	<0.1	11
	July 7	2.0	7
	August 2	1.8	10
	September 1	0.7	12
	October 6	<0.1	13
Biorka Island	February 26	2.9	41
	November 23	-------	31
	November 24	-------	3
	November 30	-------	28
	December 17	-------	26
	December 29	-------	28
	December 30	-------	20
Cape Sarichef	January 22	3.9	5
	March 10	<0.1	1
	May 12	0.3	5
	July 7	3.3	3
	July 15	2.2	2
	October 20	-------	6
	December 11	-------	11
Port Clarence	January 18	<0.1	12
	February 11	<0.1	13
	March 9	<0.1	6
	April 9	0.5	20
	May 7	<0.1	11
	June 6	<0.1	9
	July 7	1.5	13
	August 6	<0.1	18
	September 12	<0.1	21
	October 17	-------	11
	November 12	-------	10
	December 12	-------	14
Sitkinak Island	January 13	<0.1	23
	February 12	<0.1	18
	March 17	<0.1	19
	April 10	0.5	11
	May 13	<0.1	18
	June 12	5.4	15
	July 7	1.4	3
	August 11	<0.1	12
	September 13	0.9	12
	October 22	-------	10
	November 17	-------	14
	December 16	-------	10
Spruce Cape	January 7	<0.1	43
	February 10	[illegible]	40
	March 10	<0.1	<1
	April 6	0.5	39
	May 5	[illegible]	18
	June 9	<0.1	13
	July 27	1.0	<1
	August 3	0.9	12
	September 10	<0.1	4
	October 14	-------	10
	November 9	-------	16

Previous coverage in *Radiological Health Data:*

Period	*Issue*
October–November 1959	*June 1960*
October–December 1959	*July 1960*
Fourth quarter 1959, and first and second quarters 1960	*August 1961*
October 1961–April 1962	*October 1962*
May–December 1962	*August 1963*
January–December 1963	*November 1964*

Section IV—Other Data

FALLOUT RADIONUCLIDES IN MILK, TOTAL DIET, AND HUMAN BONE COMPARED TO FEDERAL RADIATION COUNCIL ESTIMATES, 1963-1964

Richard D. Grundy, Robert P. Chandler,
James R. Coleman, and James G. Terrill, Jr.[1]

Estimates of the levels of fallout radionuclides in environmental media and human bone expected in 1963, 1964, and 1965 from the atmospheric testing of nuclear weapons conducted through 1962 have been made by the Federal Radiation Council (*1,2*). Observed values for 1963 and 1964 based on surveillance measurements are presented and compared with these predictions. Discussion is centered on those ingested fallout radionuclides most significantly contributing to the internal radiation dose to man: strontium-89, strontium-90, iodine-131, and cesium-137.

Although the total diet is the most direct measure of intake of radionuclides, specific indicator foods are also important. Milk is both the single food item most often used as an indicator of the population's intake of radionuclides from the environment as well as the most rapid vector, other than air and water, by which man can be exposed. Fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically significant.

Milk

Radionuclide concentrations in milk are closely monitored by the Public Health Service's Pasteurized Milk Network (PMN) at 63 sampling locations in selected United States municipalities (*3*). Additional information on radionuclide concentrations in milk are obtained through the Atomic Energy Commission's Tri-City Diet Study (*4*) and various State milk sampling programs.

Strontium-89. Following the resumption of atmospheric nuclear testing in late 1961, an influx of strontium-89 into milk was observed by the PMN (*5*). The average monthly concentration showed a general increase and exhibited noticeable peaks in the springs of 1962 and 1963. The concentration of this radionuclide in milk declined after the spring of 1963, becoming negligible by the spring of 1964. The maximum annual average strontium-89 concentration at any stations during this period was 170 pCi/liter. The intake of radionuclides from the diet can be estimated assuming a 1-liter daily intake of milk. This would amount to 170 pCi/day.

Strontium-90. The observed strontium-90 concentrations in milk for the PMN and the Tri-City Diet Study from 1961 through 1964 are given in table 1. For consistency with the Federal Radiation Council presentation, these concentrations are presented on a "wet" or "dry" area basis (*2*), along with concentrations estimated by the Federal Radiation Council. It is observed that in the "wet" area, data produced by the two programs were in close agreement. In 1963, the PMN results were slightly below the Federal Radiation Council predictions.

In 1964, the results were slightly below the predicted concentration for both programs. Although not striking, the observed differences suggests the 1965 predictions were somewhat high, indicating that environmental contamination has not been as great as anticipated for the "wet" areas.

Considering the "dry" areas, the Tri-City Diet Study milk results were in agreement with Federal Radiation Council predicted concentrations, while PMN results were slightly higher than the predicted concentrations. The observed difference suggests the "dry" area predicted concentration for 1965 might be

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[1] Mr. Grundy is Chief, Environmental Data Unit; Mr. Chandler is Chief, Human Data Unit; and Mr. Coleman is Chief, Data Collation and Analysis Section. All are of the Radiation Surevillance Center, Division of Radiological Health; Mr. Terrill is Deputy Chief, Division of Radiological Health, USPHS, Washington, D.C.

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low, relative to the Pasteurized Milk Network results. This suggests that environmental contamination in the "dry" areas was somewhat greater than anticipated.

Iodine–131. Iodine–131 concentrations in milk for the PMN increased in 1961 with the resumption of atmospheric nuclear testing. However, as predicted, the iodine–131 had become undetectable by mid–1963 (*2*). The peak annual average was 104 pCi/liter at Palmer, Alaska, in 1962. Using the assumption of 1 liter daily intake of milk, this annual average would correspond to Range III (100–1,000 pCi/day) as defined by the FRC (*6*).

Cesium–137. Cesium–137 concentrations in milk for the Pasteurized Milk Network paralleled the strontium–90 results. A continued increase was observed from 1961 through 1964 when the peak concentration of cesium–137 in milk occurred. The annual averages in 1964 were 119 pCi/liter in the "wet" area and 86 pCi/liter in the "dry" area.

Diet

Estimates of children and teenager radionuclide intakes have been obtained since 1961, through the Institutional Total Diet Sampling Network (*7*) of the Division of Radiological Health and the Division of Environmental Engineering and Food Protection. This network, along with the Atomic Energy Commission's Tri-City Diet Study (*4*), the Food and Drug Administration's Teenage Diet Survey (*8*), the State of California's Diet Study (*9*), and the State of Connecticut's Standard Diet Study (*10*), provides nationwide estimates of dietary intakes of radionuclides. The characterization of radionuclide concentrations in the diet constitutes an important element of any integrated program of population-oriented radiation surveillance.

Strontium–89. The influx of strontium–89 into the diet was observed in the Institutional Diet samples in late 1961 following the resumption of atmospheric nuclear testing (*11*). The average daily intake was seen to reach peaks in mid–1960 and 1963, declining thereafter (*9*). This radionuclide had diminished to negligible levels by early 1964. The annual average daily intake was approximately the same in mid-1962 and mid-1963. These observations were in agreement with the Federal Radiation Council Report Number 4. The maximum annual average strontium–89 intake at any institution during this period was 182 pCi/day.

Strontium–90. Unlike strontium–89, strontium–90 has been observed in the Institutional Diet samples continuously since the inception of the network. During 1961, the network annual average strontium–90 intake was 8 pCi/day, which corresponds to approximately 7 pCi/g calcium in the diet.[2] After the resumption of nuclear testing, the average daily intake increased steadily, reaching a maximum in the spring of 1964. The network annual averages were 13 pCi/day in 1962; 25 pCi/day in 1963; and 32 pCi/day in 1964, corresponding to approximately 12, 22, and 28 pCi/g calcium, respectively. The highest annual average for an individual institution, 48 pCi/day, was observed during 1964. This corresponds to Range II (20–200 pCi/day) as defined by the Federal Radiation Council (*6*). A decreasing trend, first observed in the latter part of 1964, should be expected to continue through 1965.

Similar patterns of strontium–90 dietary intake were reflected in the Tri-City Diet Study (*8*) and the Teenage Diet Survey (*4*). Strontium–90 dietary intakes increased during 1961 and 1962, reaching a maximum in the spring of 1964.

Comparisons of these dietary results with the Federal Radiation Council estimates (*1,2*) are shown in table 2. For the "wet" area, the results from the two sampling programs were in reasonable agreement for all years, although the ratios of pCi/g calcium observed were below the values predicted by the Federal Radiation Council. In the "dry" area the observed results for both programs were also somewhat lower than the predicted ratio. However, in 1964, the Institutional Total Diet Sampling Network result, representing several sampling locations, was in closer agreement with the Federal Radiation Council predictions than the Tri-City results, which are represented by San Francisco, California.

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[2] Based upon 1.13 g calcium per day (*11*).

Iodine–131. When considering the daily intake of iodine–131, emphasis is generally placed on the contribution from fresh milk, since the normal delay between deposition and the consumption of most other dietary components provides time for significant reduction of iodine–131 by decay. The dietary intake of iodine–131 as observed in the ITDSN reached a peak in 1961, with an average annual intake of 27 pCi/day. A decrease was seen in 1962, 1963, and 1964, with annual averages being 25, 16, and 0 pCi/day, respectively. Consistent with the predictions of the FRC (*2*), iodine–131 was no longer observable in the diet by mid–1963.

Cesium–137. During 1961, the cesium–137 dietary intake, as observed in the Institutional Total Diet Sampling Network, averaged 29 pCi/day. Subsequently, the dietary intake of cesium–137 increased, paralleling the strontium–90 intake. A peak network average daily intake of 154 pCi/day was observed in 1964. This is well below the value of 4,400 pCi/day for the population at large which can be derived from International Commission on Radiological Protection recommendations (*12*). Federal Radiation Council estimates of dietary intake of cesium–137 have not been made. However, as with strontium–90, cesium–137 dietary intakes are expected to decrease in 1965. Results of the Teenage Diet Survey further substantiate this expected decrease (*8*).

Bone

Indications of the extent to which strontium–90 has entered the food chain of man have been shown by the preceding summary of results. The resultant levels of strontium–90 in man can be described by employing the ratio of pCi ^{90}Sr/g Ca in bone.

For consistency with the presentation in Federal Radiation Council Reports Numbers 4 and 6, the 0-to 4-year old age group is considered. Table 3 shows the observed pCi ^{90}Sr/g Ca in bone from AEC's Health and Safety Laboratory (HASL) and Public Health Service programs along with Federal Radiation Council estimates. Reasonable agreement is noted between the predictions and the observed data. However, the observed values are consistently about one-half the predicted values. A difference of this order is not unexpected since the predicted values are for new bone being formed, whereas a considerable fraction of the bones of individuals 0–4 years of age was old bone, which (in 1963 and 1964) had a lower strontium–90/calcium ratio than the bone most recently formed.

Estimated dose

From the observed strontium–90 in bone and cesium–137 concentrations in milk it is possible to estimate annual dose rates to children. The resultant radiation dose rate from the indicated strontium–90 concentrations in bone may be estimated from the dose conversion factor presented by the Federal Radiation Council (*13*). The highest average bone level shown (6 pCi/g Ca), would result in a dose to bone marrow of approximately 5.5 mrad in one year.

For cesium–137, the yearly dose (assuming equilibrium) can be calculated from the following:

$$D=(11)\frac{I}{W}1.44T_e$$

Where:

D = dose rate (rads/year)
I = daily intake of cesium-137 (μCi/day)
W = body weight (kg)
T_e = effective half-life (days)

For infants the effective half-life is taken to be 30 days and the body weight as 10 kg (*13*); also, it is assumed that 1 liter is the daily intake of milk. Considering the "wet" area with a 1964 average for cesium–137 of 119 pCi/liter of milk, the resultant dose would be approximately 5.7 mrad for the year.

Since both nuclides contribute to bone-marrow dose, the sum of the estimated doses is of significance (*13*). Thus, the estimated total dose to bone marrow from strontium–90 and cesium–137 would be approximately 10 mrad during 1964 for young children in the "wet" area.

For long term low-level situations, such as represented by these data, a Protective Action Guide has not been recommended by the Federal Radiation Council. Rather, annual doses from fallout equal to or greater than the numerical values of the Radiation Protection Guides (RPG's) can be used as an indication of when there is a need for careful evaluation of fallout exposures. The RPG for bone marrow for the general population is given as 170 mrad/year (*6*). Thus, in the above case, the dose rate due to strontium–90 and cesium–137 for young children in the "wet" area amounts to approximately 6 percent of the RPG.

Table 1. Annual averages of strontium-90 content of U.S. milk, 1961–1964, compared with Federal Radiation Council estimates for 1963–1965

(pCi/g Ca)

Year	"Wet area"			"Dry area"		
	New York City (Tri-City)	FRC Estimate	PMN	San Francisco (Tri-City)	FRC Estimate	PMN
1961	10	----------	10	5	----------	5
1962	15	----------	15	5	----------	10
1963	20	[a]20	25	10	[a]10	15
1964	25	[b]20	25	10	[b]10	15
1965	----------	[b]25	----------	----------	[b]5	----------

[a] Estimated in Federal Radiation Council Report No. 4.
[b] Estimated in Federal Radiation Council Report No. 6.

Table 2. Annual averages of strontium-90 content of U.S. total diet, 1961–1964, compared with Federal Radiation Council estimates for 1963–1965

(pCi/g Ca)

Year	"Wet area"			"Dry area"		
	New York City (Tri-City)	FRC Estimate	Institutional Diet	San Francisco (Tri-City)	FRC Estimate	Institutional Diet
1961	5	----------	10	5	----------	5
1962	10	----------	10	5	----------	10
1963	20	[a]30	25	10	[a]15	15
1964	30	[b]40	20	10	[b]20	20
1965	----------	[b]30	----------	----------	[b]15	----------

[a] Estimated in Federal Radiation Council Report No. 4.
[b] Estimated in Federal Radiation Council Report No. 6.

Table 3. Average strontium-90 content of human bone in the United States, for 0–4-year olds at death, 1958–1965

(pCi/g Ca)

Year	"Wet" area			"Dry" area		
	Estimated [a]	Observed		Estimated [a]	Observed	
		HASL	PHS		HASL	PHS
1958		2.0			2.0	
1959		2.7			2.2	
1960		2.4			1.8	
1961		2.6			0.9	
1962		3.1	4.0		1.1	
1963	12	5.0	4.2	9	1.9	
1964	10	6.1	[b]6.1	5	2.6	2.7
1965	8			4		

[a] 1963, 1964, and 1965 values are predicted by assuming one-fourth of the dietary level of strontium-90 is laid down in new bone in 0- to 4-year old children (*1, 2*), and that the strontium-90/calcium ratio of old bone in this group is the same as that of new bone.
[b] Values based upon results for January through June 1964.

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Summary

The estimates made in Federal Radiation Council Reports Number 4 and 6 regarding the maximum concentrations of radionuclides in the environment and man have been essentially verified by recent surveillance data. The peak intake of radionuclides by the population groups selected appears to have occurred in 1964. It is concluded, therefore, that the predictions made in Federal Radiation Council Reports Number 4 and 6 and the radiation doses projected over the next 30 and 70 years are valid and reasonable for the situation as it exists currently.

For the situation wherein the major nuclear powers are abiding by the atmospheric test ban treaty, current surveillance operations are appropriate. This is due in large measure to cooperation between Federal and State agencies in developing nationwide coordinated surveillance programs. Such related surveillance programs complement each other and frequently provide corroborative information. In general, current surveillance activities are designed to yield measurements of environmental radiation levels which can ultimately be translated to estimates of average doses to population groups. Based upon predictions of dietary contamination levels anticipated in 1963 and subsequent years, the Federal Radiation Council concluded in Reports Number 4 and 6 that health risks from radioactivity in food over the next several years are too small to justify protective actions to limit the intake of radionuclides by food, particularly milk and dairy products. The observed radionuclide levels are in agreement with these predictions, and therefore the conclusions of the Federal Radiation Council apply.

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RADIOACTIVE CERAMIC GLAZES

Leonard F. Menczer[1]

During the past several years articles have appeared in news media concerning radioactivity in certain types of glazed earthware (tableware). Since there is little in the literature on this subject, a brief review may be indicated, including additional information secured by the author.

Historical aspects

The use of uranium compounds to produce pigmented glazes for ceramicware such as platters, pitchers, vases, water mugs, coffee cups, and demitasses was reported as early as 1906 (*1*). The colors produced by using uranium source materials in the glazing process range from brilliant orange-red to lemon-yellow. At low firing temperatures, and in a high lead glaze, uranium pigments produce a red color, while in an alkaline glaze they develop a yellow color. The forms in which uranium is usually used are black oxide of uranium (UO_2) and sodium uranate (Na_2UO_4) (*2*). The radioactivity of such glazed materials has been recognized for some time, and their use as sources for classroom demonstrations of radioactivity has been suggested (*3*). This use of ceramicware, as well as normal use as eating utensils, has been described as unlikely to present a health hazard (*4*).

The use of uranium source materials for ceramic glazes was interrupted in 1943, when uranium ores became unavailable except for atomic development. Just how large a stock of uranium pigment materials was on hand at the several pottery manufacturing plants in the United States in 1943 when controls were placed on uranium ores, and just how long that supply lasted is difficult to determine. It is believed that, due to the lack of uranium ore supply, by 1944–1945 the use of uranium pigments in ceramic glazes was discontinued.

It is reasonable to assume that millions of such dishes and drinking ware were manufactured and sold prior to 1944–1945 and that many of these continue in use today.

It was not until about 1959 that uranium oxide was again commercially available. Since then, however, it has been used under Atomic Energy Commission regulation, which imposes conditions concerning the safety of the manufacturing process and limits the quantities of uranium in the final product (*5*). Excerpts from current regulations governing the quantity of uranium which can be used in ceramic glazes are set forth below:

> "Exemptions
>
> "40.13 Unimportant quantities of source material
>
> "(c) Any person is exempt from the regulation in this part and from the requirements for a license set forth in section 62 of the Act to the extent that such person receives, possesses, uses, transfers, or imports into the United States:
>
> " . . . (2) Source material contained in the following products: (i) glazed ceramic tableware, provided that the glaze contains not more than 20 percent by weight source material; (ii) glassware, glass enamel, and glass enamel frit containing not more than 10 percent by weight source material; but not including commercially manufactured glass brick, pane glass, ceramic tile or other glass, glass enamel, or ceramic used in construction . . ." (*6*).

To clarify the term "Source Material" the following definition is used by the Commission:

> "40.4 Definitions
>
> "(h) "Source Material" means (1) uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight one-twentieth of 1 percent (0.05 percent) or more of (i) uranium, (ii) thorium or (iii) any combination thereof. Source Material does not include special nuclear material" (*6*).

The clause "not more than 20 percent by weight source material" developed "through expression from various manufacturers as to the quantities of source material necessary to give desired colors in the glaze. This quantity of source material in the glazed ceramic tableware was evaluated by the AEC staff from the radiological safety standpoint, taking into account such considerations as the method of incorporating the radioactive material into the glaze, the type of radiation involved, the radiation levels at varying distances from the glazed ceramic tableware, the conditions of use of the tableware, and the parts of the body likely to receive radiation exposure in connection with the use of the tableware. The radiation safety evaluation made indicated that the radiation exposure to persons possessing and using glazed ceramic tableware containing not more than 20 percent source material in the glaze would be insignificant" (*7*).

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[1] Dr. Menczer is Radiological Health Officer, Hartford Health Department, City of Hartford, Connecticut.

More recently (March 1965), the AEC published criteria for the approval of products intended for use by the general public, containing byproduct material and source material (*8*). Essentially, the principal considerations in these criteria are similar to those mentioned above in evaluating glazed ceramic tableware.

AEC estimates of exposure from handling such tableware have been made on the basis that the highest exposure would be to the hands. The AEC has indicated that even if it is postulated, as an example of an extreme period of exposure, that there is a continuous contact with the tableware for as long as 1½ hours per day, with a radiation level of 5 mrad per hour at contact, then these conditions would produce an exposure of 7.5 mrem per day to the hands, or 2.6 rems for a 50-week period. This estimated exposure may be compared with 75 rems permissible exposure to the hands for a 50-week period for workers in the atomic energy industry (*9*).

From the inquiries by the writer, it was found that at least five manufacturers of china and earthenware at one time or another prior to the mid-forties used glazing pigments containing uranium compounds. However, only one of these five manufacturers as of 1963 used this type of pigment. In more recent years, several additional companies have made application for licensure from AEC to use depleted uranium materials for glazes used in ceramic or glassware manufacture.

Reviewing the above background information, it would appear that the public health interest in this subject centers on quantitating information on a number of problems. One of these is to ascertain the radioactivity associated with uranium pigment-glazed ceramicware manufactured prior to 1944–1945. Another is to determine the radioactivity of ceramicware manufactured after 1949 with glazing pigments consisting of depleted uranium oxide. Finally, if warranted, actual conditions of use of ceramicware in the general population should be determined to establish more precisely the dosimetry involved. Information bearing on the first of these problems is presented below.

Findings

It is assumed that all earthenware in this study was manufactured prior to the 1940's. This assumption is based on the fact that the individuals from whom the earthenware was collected stated in effect: "We've had these dishes for the past 20 to 30 years."

As the first step in evaluating the radioactivity associated with a wide assortment of glazed earthenware (tableware) collected in 1963, film badges were placed in direct contact with the glazed surfaces of selected items for a 24-hour period. Badge holders were not used, cadmium and copper filters being taped to the badges. Table 1 lists the findings of gross beta and gamma radiation by color and type of earthenware, and location of badge. In some instances, double badges were employed in order to check on the consistency of the film badge readings.

Although a wide assortment of earthenware was submitted to a cursory survey using a CDV–700 Geiger-Mueller survey meter for the screening procedure, only selected colors and color combinations were found to be radioactive. For example, all orange-pigmented products of the five manufacturers contained varying amounts of radioactivity. One manufacturer's products were blended color combinations such as chocolate brown with orange speckling; green, orange, and blue; and one set, blue-green on the inside (not radioactive), orange on the outside (radioactive). Not all lemon-yellow items showed activity. Those that did were substantially less radioactive than the orange-pigmented products.

From a review of table 1, it will be noted that gross readings (beta plus gamma) for the orange earthenware tested range from a low of 3.8 mrad/hr to a high of 19.6 mrad/hr. When examined for their beta and gamma components, gamma readings ranged from zero to 7.5 mrad/hr. In several cases (badges 17, 19, and

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Table 1. Film badge readings obtained from surface contact with ceramic glazes

Badge No.	Color	Type of earthenware	Location of badge	24-hour reading (mrad)				mrad/hr maximum gamma plus beta
				Minimum gamma	Maximum gamma	Beta	Total maximum plus beta	
1 & 2	Chocolate brown	Dinner dish round—scalloped edge	Center of plate	0 0	70 70	140 140	210 210	9 9
3 & 4	Orange	Same	Same	0 0	50 60	130 140	180 190	8 8
5 & 6	Orange	Dinner dish square—scalloped corner	Same	0 0	50 50	140 150	190 200	8 8
7 & 8	Orange	Dinner dish square—scalloped corner	Same	0 0	90 70	150 160	240 230	10 10
9 & 10	Orange	Dinner dish round	Same	0 3	40 40	90 90	130 130	5 5
11 & 12	Orange	Saucer round	Same	3 0	15 60	160 160	175 220	7 9
13 & 14	Orange	Cereal bowl	Same	27 15	140 180	330 280	470 460	20 19
15	Orange	Saucer round—scalloped edge	Same	0	85	160	245	10
16	Orange & blue	Coffee cup	Lip portion outside	0	70	160	230	10
17 18	Orange	Coffee cup	Lip portion inside Lip portion outside	0 0	80 50	210 110	290 160	12 7
19 20	Orange	Water mug	Lip portion inside Lip portion outside	0 0	80 50	260 160	340 210	14 9
21 22	Orange	Coffee cup	Lip portion inside Lip portion outside	6 0	110 70	240 190	350 260	15 11
23 & 24	Orange	3-sectional dinner plate	Center	0 0	50 40	90 110	140 150	6 6
25 26	Green, orange, & blue	Matching dish and bowl	Dish, edge orange Bowl, on orange base	0 0	20 90	70 280	91 370	4 15
27 & 28	Lemon yellow	Dinner dish	Center of plate	0 0	3 3	10 10	13 13	0.5 0.5

21), where film badges were taped to the inside surfaces of coffee cups and mugs, substantially higher readings were observed than from badges taped to the outside. This may be simply an effect of geometry.

Discussion

Film dosimetry presents several problems. One encountered in this study was inadequate definition of beta–gamma energies, such as those occurring at the surfaces of ceramic glazes. Hence, the accuracy of the beta and gamma components reported in table 1 may be questioned. In general, the 0.010-inch copper filter on the film badge is considered to be opaque to beta radiations; however, this may not be true for beta particles with energies greater than 0.7 MeV. In addition, some of the soft gamma components are difficult to distinguish from higher energy beta particles. For these reasons a range of the gamma components is expressed in table 1 under column headings "Minimum gamma" and "Maximum gamma."

It is of interest to compare the findings in table 1 with reports received from the Atomic Energy Commission and the Public Health Service for, presumably, currently produced earthenware. These reports were issued as a result of inquiries from private individuals and official agencies following wide newspaper publicity in early 1963 in Connecticut. A communication from a representative of the AEC stated: "The beta radiation level on the dishes . . . is about the same as all dishes using uranium trioxide as a coloring agent. They read about 2 millirad per hour (2 mrad/hr) on contact . . . The amount of gamma or penetrating radiation which comes from the dishes is barely detectable with sensitive measuring instruments. It is barely distinguishable from natural background radiation" (*10*). A communication from the PHS states: "To be specific, their tests (the AEC) showed that about 14 percent 'source material' was used in the glaze for tangerine-colored dishes (which required more of the 'source material' in order to attain the desired color than would be necessary for dishes with other colors), and with this concentration of 'source material' dose rate determinations at the surface of such dishes showed about 2 mrad/hr beta-gamma readings of about 0.5 mrad/hr gamma readings . . ." (*11*).

The average results reported by this study for dishes produced before 1944–1945 differ by approximately a factor of 5 from those reported by the AEC for dishes probably manufactured after 1949. However, the average ratio of beta-gamma to gamma absorbed dose observed in this study are reasonably consistent with the ratio determined from the AEC data (approximately 3.5 vs. 4, respectively). A number of possible explanations for these observed differences in activity are advanced:

a. Ceramic glazes produced during different periods (pre–1944–45 and post–1949) were being compared.
b. Sample geometries varied and/or different testing techniques were used.
c. The products of five manufacturers were investigated in this report while the AEC study may have been limited to the products of one manufacturer.
d. Data as to whether or not comparable glazes were being tested is lacking.
e. The quantity of glaze slurry employed may vary between samples.

Employing the values obtained in this survey, it is estimated that radiation exposure to the hands (using a 1½-hour daily period of exposure) ranges from a low of 2.0 rems per 50-week period to a high of 10.3 rems per 50-week period. The latter figure may be compared with the 75 rems allowable exposure to the hands of workers in the atomic energy industry. The 1½-hour period assumed for daily exposure to the hands would probably produce an "upper limit" of exposure; under conditions of normal use the duration of exposure would be shorter.

Summary

Utilizing the film badge method, gamma and beta-gamma radiation measurements were made at the surfaces of specific types of glazed ceramicware; these were compared with measurements reported by others. While the results were not strictly comparable, some of the differences observed may have been due to such variables as the geometry of the conditions under which the readings were taken and the thickness of the glaze. Also, the time periods (pre–1944–45 vs. post–1949) during which these glazed earthenware samples were produced may have been a factor.

The amount of exposure contributed by the glazed ceramicware discussed in this report is admittedly small; however, the documentation of any increment of artificial exposure, such as that discussed in this report, is of public health interest.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for the Lawrence Radiation Laboratory, Los Almos Scientific Laboratory, and the Mound Laboratory.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentrations limits, are applicable to effluents released from AEC installations.

1. Lawrence Radiation Laboratory[2]

July–December 1964

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (figure 1). Technical facilities include a 6.3 Bev proton accelerator (Bevatron), a 700-MeV cyclotron, a 10-MeV linear accelerator, an 88-inch cyclotron, and various chemistry and physics laboratories.

The environmental sampling program includes monitoring of the atmosphere, surface and ground waters, sewage, and rain or dry deposition. Three types of atmospheric samples are taken: stack samples, local area samples, and perimeter samples.

Approximately 110 "stacks" with potential for releasing radioactive contaminants are sampled continuously. One-inch diameter filters are used at a flow rate of 1 liter per minute. The filters are changed weekly and counted for beta activity by an end-window Geiger-Mueller tube and for alpha activity by a thin-window proportional counter. Local area and perimeter air samples are taken at locations on the Laboratory site and at the property line, respectively. The samples are taken on 4- x 9-inch HV-70 filter paper at 4 cfm. The filters are changed weekly, counted for alpha activity by a thin-window proportional counter, and for beta activity by a 30 mg/cm^2-window Geiger-Mueller tube. A 40-percent loss in the alpha count is assumed for self absorption. The average levels of activity observed in each type of sample are given in table 1.

Rain or deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and

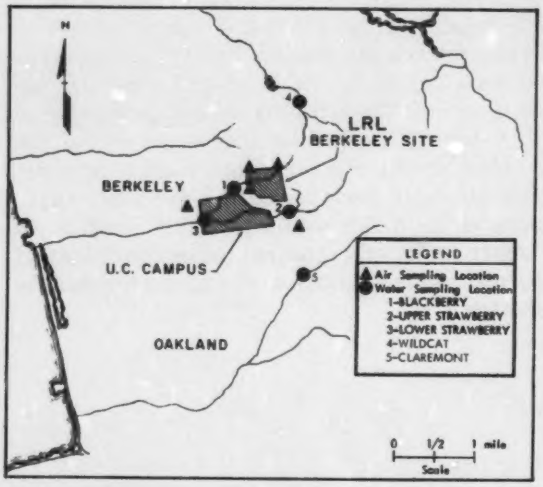

Figure 1. Environmental sampling locations at the Berkeley site

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[1] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from "Lawrence Radiation Laboratory Environmental Radiation Levels—Berkeley and Livermore, Second Half 1964 and Annual Summary 1964."

Table 1. Atmospheric monitoring, Berkeley site
July–December 1964

Sampling locations	Number of samples	Alpha (pCi/m³)	Beta (pCi/m³)
Stacks	4,000	0.01	1.24
Local area	249	0.00	0.46
Perimeter	98	0.01	0.55

perimeter sites. Rain samples are poured out and evaporated in beakers. If the bag is dry, it is rinsed out with dilute nitric acid, and the resulting solution is then evaporated. Final evaporation is conducted in 2-inch diameter stainless steel planchets, which are then flamed and coated with a thin film of lacquer. These planchets are counted for alpha activity in an internal-flow proportional counter and for beta activity with a thin-window, low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Deposition data are given in table 2.

Table 2. Total deposition, Berkeley site, July–December 1964

Location	Number of samples	Alpha (nCi/m²)	Beta (nCi/m²)
Local area	60	0.0754	13.51
Perimeter	24	0.1428	13.89

Water samples are taken from sewers, onsite streams, and offsite streams. Two sewer lines serve the LRL area. The Hearst sewer receives waste from the larger part of the area. A sampling system takes a continuous proportional sample from the Hearst sewer as it leaves the Laboratory boundary. Samples are also taken of acid waste feeding into the Hearst sewer from Buildings 70, 70A, and 71. The Strawberry sewer receives waste from the southeast part of the Laboratory site. Building 74 is the most likely contributor of radioactivity to this sewer line. The two acid waste systems from Building 74 are sampled individually on a continuous basis. Strawberry and Blackberry Creeks comprise the Laboratory's storm drainage. These are sampled weekly at three locations. Two other nearby offsite creeks are also sampled weekly. All water samples are handled in the same manner as rain samples. The results from the water sampling program are presented in table 3.

Table 3. Water monitoring, Berkeley site
July–December 1964

Type of sample	Number of samples	Alpha (pCi/liter)	Beta (pCi/liter)
Sewage:			
Hearst sewer	81	3.75	32.0
Strawberry sewer	41	<.4	66.7
Tap water	33	.06	5.5
Surface water:			
Onsite streams	78	.00	11.0
Offsite streams	51	.49	4.3

Livermore Site

The Livermore site of LRL is located about 50 miles southeast of San Francisco, California (see figure 2). Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

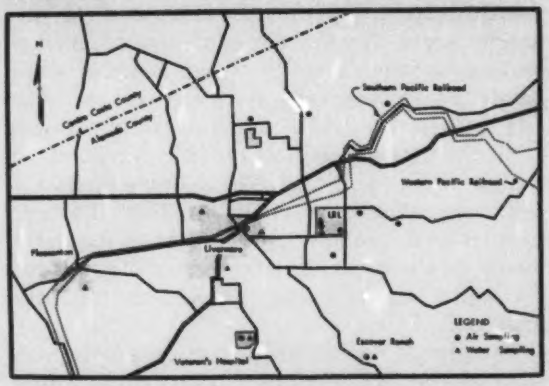

Figure 2. Sampling locations at the Livermore site

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the Laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the Laboratory. Samples are collected at a rate of 4 cfm on 4- x 9-inch HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted, to eliminate the effect of natural radon and thoron daughters. The alpha activity remaining is measured with a counter equipped with a zinc-sulfide scintillation detector with a counting efficiency of about 24 percent for 5.1 MeV. The beta activity is measured with a Geiger-Mueller tube using strontium–90 in equilibrium with yttrium–90 as the standard. Alpha activity in air samples averaged 0.003 pCi/m^3, while beta activity averaged 0.23 pCi/m^3.

Domestic water samples are collected monthly from two onsite wells and in six nearby areas. The average radionuclide concentrations in the domestic water samples were below the limit of sensitivity for beta activity (41 pCi/liter), while alpha activity ranged from the limit of sensitivity (8.9 pCi/liter) to a high of 58.0 pCi/liter. The average alpha activity was slightly below 10 pCi/liter. The gas proportional counter used in these measurements has a counting efficiency of 34 percent for alpha emitters and 50 percent for beta emitters.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha activity fluctuated from the limit of sensitivity (5.0 pCi/g) to 13.0 pCi/g. The beta activity fluctuated from the limit of sensitivity (23.0 pCi/g) to 68.0 pCi/g.

Samples are collected every Monday, Wednesday, and Friday at the sewer line leaving the southwest project boundary, where it connects with the Livermore domestic sewer line. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that the liquid effluent from the laboratory is not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner). Radioactivity levels in sewage oxidation ponds and dried sludge are summarized in table 4.

Table 4. Environmental sampling, Livermore, July–December 1964

(Average concentrations)

Type of sample	Alpha (pCi/liter)	Beta (pCi/liter)
Sewage	92	44
Oxidation ponds	15	50
Dried sludge	34	27

Site 300

Site 300 is located in a very sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The seven air samplers at Site 300 are operated at about 50 cfm on a continuous basis, but the filter papers are changed on an irregular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible source of underground water. No samples are collected from streams since there is no flow during the summer and fall months and only sporadic flow in the winter.

All air and water samples are processed at the Laboratory in Livermore. Soil samples are collected monthly at seven offsite locations. Only top layer soil is collected to determine fallout concentrations. The average radioactivity levels in all types of samples are summarized in table 5.

Table 5. Environmental sampling, Site 300, July–December 1964

(Average concentrations)

Type of sample	Alpha	Beta
Air (pCi/m^3)	0.0045	0.29
Soil (pCi/g)	7	24
Onsite wells (pCi/liter)	8.9–30	41–46

Recent coverage in *Radiological Health Data:*

Period	*Issue*
Second half 1961	*October 1962*
Calendar year 1962	*October 1963*
Calendar year 1963	*October 1964*
First half 1964	*May 1965*

2. Los Alamos Scientific Laboratory[3]
Calendar Year 1964

University of California
Los Alamos, New Mexico

As part of the environmental monitoring program at Los Alamos, measurements of air particulate radioactivity, activity in precipitation, and gamma background are made periodically. The samples have been taken on the roof of building TA–50 (about 1¾ miles southeast of the Administrative Building, the former location) starting in March 1963. Gamma-background surveys were discontinued in March 1963.

Air monitoring

Airborne radioactive particulate matter is collected on 4-inch-diameter filters. The sampling rate was reduced from 46 m^3/hr in 1962 to 25.5 m^3/hr in 1963, due to the addition of an activated charcoal filter behind the first filter. Air samples are ordinarily collected for 24-hour intervals during the work week; 72-hours weekend samples are collected.

The filters are counted for beta activity 7 days after collection in a thin-window (methane) flow proportional counter, with an overall efficiency for ^{90}Sr–^{90}Y of 50 percent. During the year, air samples averaged 0.69 pCi/m^3 for beta activity, with a maximum of 3.75 pCi/m^3 occurring on October 26, 1964.

Precipitation monitoring

Collection is made in a 0.4 square meter rain collector which delivers 1 liter of water for each 0.1 inch of precipitation. It has been found that this arrangement collected activity even during relatively dry periods. By washing down the sides of the collector with 1 liter of distilled water, a suitable sample is obtained. These "wash" samples, as well as any precipitation, are reduced in volume, dry-plated on 1-inch stainless steel planchets, and counted in an automatic beta counting system, installed in late 1963. This system has a gas-flow proportional counter, which provides increased efficiencies and lower background. (Counting was previously done in an end-window Geiger-Mueller counter with a window thickness of 1.9 mg/cm^2.) During the year, daily deposition samples averaged 236 pCi/m^2 for beta activity, with a maximum of 10,894 pCi/m^2 occurring on April 29, 1964.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1960–1961	*October 1962*
1962–1963	*October 1964*

3. Mound Laboratory[4]
July–December 1964

Monsanto Research Corporation
Miamisburg, Ohio

Of the radionuclides in use at Mound Laboratory, only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants. No measurable amounts of penetrating radiation such as gamma or hard beta have been contributed to the environment by the Laboratory during the period covered by this report.

The environmental monitoring program, conducted by the Monsanto Research Corporation, is planned and coordinated with regard to all of the various projects performed in the Laboratory. Air and water monitoring methods and results are discussed below.

Air monitoring

A continuous air monitor for measurement of tritium, and particulate air sampling equipment for measurement of alpha activity, are mounted on a 1-ton panel truck for use in the routine monitoring of the environmental air at 95 locations selected within a radius of 20 miles. The choice of sites on a given day depends on the wind direction at the time of collection.

During the 6-month period ending December 1964, 298 samples were taken for determination of tritium in air. In all cases tritium was nondetectable.

Monitoring for possible polonium–210 and plutonium–239 released to the environment is accomplished by determination of long-lived gross alpha activity on filter paper samples.

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[3] Summarized from "Beta-Gamma Radioactivity in Environmental Air at Los Alamos, New Mexico, for 1964" (LA–3245–MS).

[4] Summarized from "Environmental Monitoring Report: July-December 1964 and 1964 Summary" (MLM–1241).

Counting is done in a low-background proportional counter. Sufficient delay time is allowed after collection to minimize interference from the daughter products of radon and thoron. The measured concentrations of alpha activity in air are summarized in table 6. No specific determinations of polonium–210 or plutonium–239 were made, since the alpha activity remained substantially below the environmental MPC's for these nuclides.

Table 6. Long-lived alpha concentrations in air in the Mound Laboratory environment, July–December 1964

Direction from laboratory relative to wind	Number of samples	Concentration (pCi/m³)
Upwind	54	0.0027
Downwind	323	0.0042

Water monitoring

Liquid radioactive waste materials from polonium operations at the Laboratory are processed in a special waste disposal plant designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River. Liquid waste from plutonium work is small in volume, is handled separately as a packaged waste, and is not discharged to the river. Helium–3, which is purified at the Mound Laboratory, contains small quantities of tritium. Liquid wastes from this work, also small in volume, are treated (diluted with water when necessary) to assure that the radioactivity content is below the maximum permissible concentration before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami River as shown in figure 3. The drainage ditch carries away all storm sewer water and liquid tritium wastes from the plant site. Sampling location number 2 is located at the point of discharge of the laboratory effluent to the Great Miami River, and number 6 is 5 miles downstream from the effluent outlet.

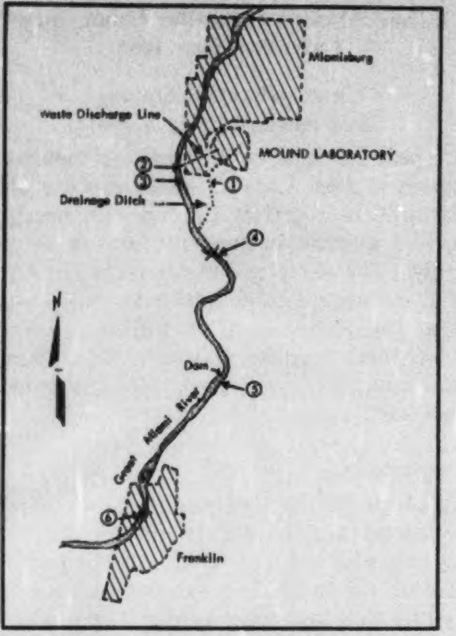

Figure 3. Water sampling locations in Great Miami River, Mound Laboratory

All of the river samples are analyzed for polonium–210. The drainage ditch samples and some of the river samples are analyzed for tritium. Average concentrations of tritium and polonium–210 are given in table 7.

Table 7. Offsite water monitoring for polonium-210 and tritium from Mound Laboratory, July–December 1964

Nuclide and station number (see figure 3)	Number of samples	Concentration (pCi/liter)
Polonium-210		
2 (effluent)	28	558
3 (250 yards downstream)	28	85
4	28	1.8
5	28	5.4
6	28	0.9
Hydrogen-3 (tritium)		
1 (drainage ditch)		1,000,000
2 (effluent)		0.0
4		0.0

Recent coverage in *Radiological Health Data:*

Period	*Issue*
January–June 1962	*March 1963*
July 1962–June 1963	*April 1964*
July–December 1963	*November 1964*
January–June 1964	*May 1965*

REPORTED NUCLEAR DETONATIONS, OCTOBER 1965

In early October 1965, the Atomic Energy Commission announced detection of seismic signals from a U.S.S.R. nuclear testing area. Later in the month, the Department of Defense announced a United States nuclear test, conducted by the Defense Atomic Support Agency.

Seismic signals recorded on October 8 indicated that a disturbance occurred in the Soviet Nuclear testing area in the Semipalatinsk region equivalent to a low to low-intermediate yield nuclear explosion. (Low is less than 20 kilotons of TNT equivalent; low-intermediate is 20–200 kilotons.)

The United States detonated an 80-kiloton thermonuclear device almost a half-mile underground on Amchitka Island, Alaska, on October 29, 1965. The purpose of this project was to obtain information on seismic signals from underground nuclear tests and their long-distance travel times. Such information may be useful in distinguishing between natural earthquakes and man-made nuclear detonations that are detected by seismographic equipment. The Division of Radiological Health participated in the project, providing offsite radiological health and safety support services, including the distribution of film badges, and sampling of air, water, milk, and vegetation. Following the event, all radiation monitoring instruments gave background readings only.

RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Synopses of contributed articles are presented below in reference card format for the reader's convenience.

DEPOSITION OF FALLOUT CESIUM–137 AT FORT COLLINS, COLORADO, 1962–1964. *D. W. Wilson, G. M. Ward,* and *J. E. Johnson* (Colorado State University). *Radiological Health Data, Vol. 6, December 1965,* pp. 675–676.

As part of a study of the transfer of cesium–137 to man via the food chain, Colorado State University investigators have accumulated 3 years' data on cesium–137 deposition at Fort Collins. The results include the following annual cesium–137 depositions: 4.14, 16.0, and 15.8 mCi/mi^2 for 1962, 1963, and 1964, respectively.

SUMMARY OF RESULTS OF INSTITUTIONAL TOTAL DIET SAMPLING NETWORK, 1961–1964. *R. G. Grundy, C. Calvert,* and *A. G. Berger* (Division of Radiological Health, *PHS*). *Radiological Health Data, Vol. 6, December 1965,* pp. 691–698.

Trends in radionuclide intakes are developed from a 4-year accumulation of diet sampling data for 21 cooperating institutions. Particular note is made of average and range of total dietary, calcium, and potassium intakes over the period. Total dietary and calcium intakes over the period approach a normal distribution, while potassium intake is skewed toward higher intake values. A general increasing trend in radionuclide intakes until 1964 was noted following atmospheric nuclear tests in late 1961 and 1962. Intakes of shorter-lived nuclides reached maximum levels during 1962–1963 and declined to below detectable levels in 1964. A decreasing trend was found for both cesium–137 and strontium–90 intakes in late 1964.

THE HALF-TIME OF CESIUM–137 IN MAN. *T. F. McCraw* (Atomic Energy Commission). *Radiological Health Data, Vol. 6, December 1965,* pp. 711–718.

Collected data on measured values of the cesium–137 half-time in man are presented and a model is suggested for expressing cesium–137 biological half-time as a function of age. The utility of the model is demonstrated in cesium–137 dose and body-burden estimations for various age groups in an exposed population. Dose for a given intake of cesium–137 is shown to vary by a factor of about two because of changes in half-time and body weight.

For assumed intakes of milk, the cesium–137 doses for different ages may vary by a factor of four or five. The time of maximum cesium–137 body burdens related to an acute contaminating event and milk consumption is shown to occur in children under 1 year within 20 days of the event. In the long-term situation noted in 1964, males 15 to 20 years of age were shown to have the highest body burdens from the use of fresh whole milk. Children under 1 year of age had the lowest body burdens.

THE RELATION BETWEEN CESIUM–137 IN MAN AND HIS DIET IN THE CHICAGO AREA. *P. F. Gustafson* (Argonne National Laboratory). *Radiological Health Data, Vol. 6, December 1965,* pp. 719–722.

The relation between cesium–137 content of the Chicago diet and body burdens of human subjects was examined on the basis of cesium–137/potassium ratios. Diet ratio data were found to coincide with the *in vivo* ratios when transformed by a factor of 3.0 and advancing the diet ratio in time by 4 months. By extrapolation of the transformed diet ratio or measurement of *in vivo* ratio curves, the *in vivo* ratio was projected to range from 70 pCi $^{137}Cs/g$ K in early 1966 to 50 pCi $^{137}Cs/g$ K by the end of the year.

Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network
August 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators report (by telephone) field estimates greater than 10 pCi/m^3 (except for Hawaii, Alaska, and Puerto Rico, which report estimates greater than 5 pCi/m^3) to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Field estimates and laboratory measurements of daily concentrations and the estimated ages for selected samples are reported in the monthly RSN report (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Sampling and analytical procedures

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1,800 cubic meters of air are drawn through a filter during the 24-hour sampling period. The filters are forwarded to the RSN laboratory in Rockville, Maryland, where the gross beta activity is measured 4 days after the sampling period and again 7 days later if the net count is 2,000 cpm (approximately 1 pCi/m^3). By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated and the

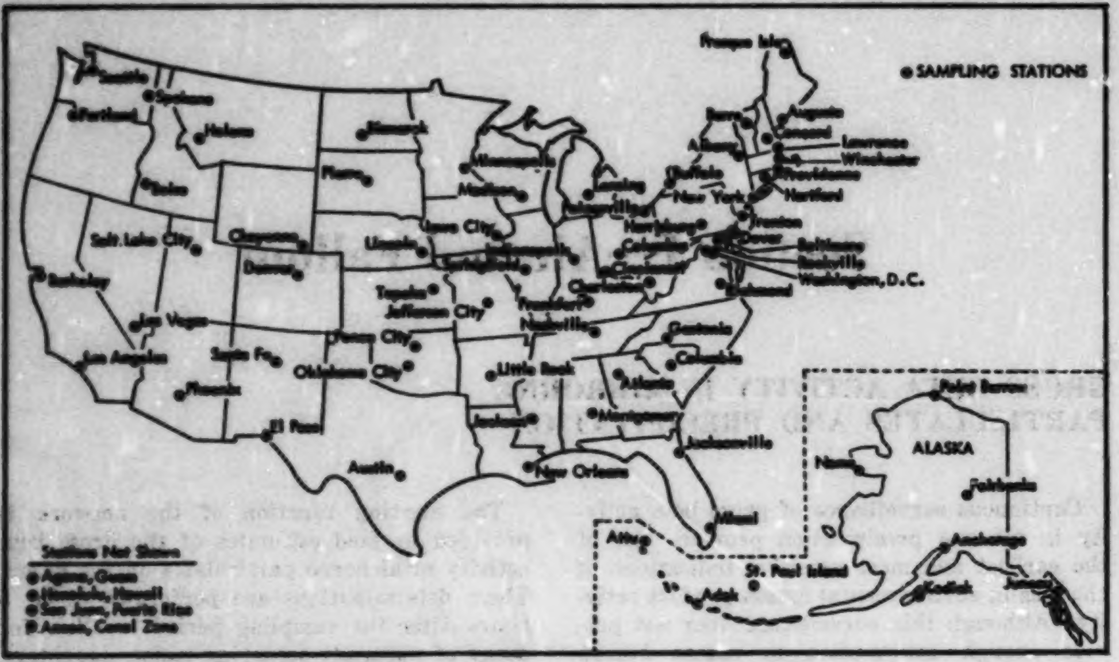
Presque Isle
SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Salt Lake City
Berkeley
Las Vegas
Los Angeles
Phoenix
Santa Fe
El Paso
Austin
Cheyenne
Denver
Bismarck
Pierre
Lincoln
Topeka
Jefferson City
Dodge City
Oklahoma City
Minneapolis
Madison
Iowa City
Indianapolis
Springfield
Frankfort
Nashville
Little Rock
Jackson
New Orleans
Lansing
Painesville
Buffalo
New York
Harrisburg
Columbus
Cincinnati
Charleston
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

activity at time of collection determined.[1] Additionally, analyses for specific radionuclides may be performed.

The total precipitation is sampled continuously at most RSN stations on a daily basis, using funnels with collection areas of 0.4 square meter. If the rainfall exceeds 0.2 inch, the precipitation sample is analyzed for gross beta activity (*1*). Additionally, analyses for specific radionuclides may be performed.

In the laboratory the gross beta activity in evaporated precipitation samples is calculated by the same method used for analyzing the air filters. Total deposition for the sample is determined by:

$$\text{Deposition (nCi/m}^2\text{)} = \frac{\text{concentration (pCi/liter)} \times \text{precipitation depth (mm)}}{1{,}000}$$

Selected air and precipitation samples are analyzed by gamma spectrometry to determine the presence of fresh fission products. The method discussed by Burrus (*3*) and Covell (*4*) was adopted for resolving the complex gamma spectra.

Results

Monthly values of gross beta activity in air, total deposition and depth of precipitation are given in table 1 for August 1965. Time profiles of gross beta activity in air for eight stations are shown in figure 2.

Levels of activity remained low. The maximum value measured during August 1965 was 0.39 pCi/m³ at Portland, Oregon, on August 1. Of the 1,924 samples collected, 63 percent contained activities less than 0.10 pCi/m³.

Gamma scans were performed on 109 air samples and traces of long-lived ^{144}CePr, ^{137}Cs, ^{106}RuRh, ^{54}Mn, ^{65}Zn and ^{125}Sn were identified. Only six precipitation samples measured 200 pCi/liter or more.

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[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

Table 1. Gross beta activity in surface air and precipitation, August 1965

Station location		Air surveillance						Precipitation measurements	
		Number of samples		Gross beta activity, pCi/m^3			Last profile in *RHD*	Total depth (mm)	Total deposition (pCi/m^2)
		Air	Ppts	Maximum	Minimum	Average [a]			
Ala:	Montgomery	31	5	0.21	<0.10	<0.11	May 65	153	<31
Alaska:	Adak	30	NS	0.10	<0.10	<0.10	Sep 65		
	Anchorage	23	5	0.20	<0.10	<0.11	May 65	25	<5
	Attu Island	9	NS	0.10	<0.10	<0.10	Oct 65		
	Fairbanks	24	4	0.14	<0.10	<0.10	Jun 65	28	<6
	Juneau	15	6	0.30	<0.10	<0.13	Jul 65	55	<11
	Kodiak	8	NS	0.10	<0.10	<0.10	Aug 65		
	Nome	2	NS	0.10	<0.10	<0.10	Dec 65		
	Point Barrow	23	NS	0.10	<0.10	<0.10	Nov 65		
	St. Paul Island	29	NS	0.10	<0.10	<0.10	Mar 65		
Ariz:	Phoenix	30	NS	0.17	<0.10	<0.11	Jul 65		
Ark:	Little Rock	23	3	0.20	<0.10	<0.12	Jun 65	45	<9
Calif:	Berkeley	20	1	0.14	<0.10	<0.10	Aug 65	4	<1
	Los Angeles	31	1	0.16	<0.10	<0.10	Dec 65	1	
C. Z:	Ancon	17	NS	0.10	<0.10	<0.10	Aug 65		
Colo:	Denver	30	NS	0.21	<0.10	<0.13	Aug 65		
Conn:	Hartford	30	11	0.27	<0.10	<0.12	Jul 65	60	<14
Del:	Dover	19	NS	0.23	<0.10	<0.14	May 65		
D. C:	Washington	30	9	0.27	<0.10	<0.13	Nov 65	86	<17
Fla:	Jacksonville	30	16	0.18	<0.10	<0.10	Jun 65	245	<40
	Miami	30	8	0.12	<0.10	<0.10	Jul 65	73	<15
Ga:	Atlanta	5	NS	0.26	0.16	0.20	Apr 65		
Guam:	Agana	31	NS	0.12	<0.10	<0.10	Apr 65		
Hawaii:	Honolulu	31	4	0.14	<0.10	<0.10	Oct 65	33	<6
Idaho:	Boise	27	3	0.20	<0.10	<0.12	Oct 65	16	<3
Ill:	Springfield	28	1	0.31	<0.10	<0.15	Nov 65	5	1
Ind:	Indianapolis	24	12	0.23	<0.10	<0.14	Apr 65	76	<15
Iowa:	Iowa City	28	8	0.22	<0.10	<0.13	Aug 65	107	<22
Kans:	Topeka	31	9	0.21	<0.10	<0.13	May 65	107	<22
Ky:	Frankfort	30	5	0.28	<0.10	<0.15	Nov 65	20	<4
La:	New Orleans	31	15	0.14	<0.10	<0.10	Nov 65	250	<53
Maine:	Augusta	31	11	0.23	<0.10	<0.13	Dec 65	88	<18
	Presque Isle	24	9	0.24	<0.10	<0.12	Aug 65	108	<22
Md:	Baltimore	21	8	0.32	<0.10	<0.16	Jul 65	55	<11
	Rockville Lab	16	NS	0.21	<0.10	<0.13	Oct 65		
Mass:	Lawrence	29	7	0.30	<0.10	<0.16	May 65	52	<11
	Winchester	29	7	0.21	<0.10	<0.12	Sep 65	40	<8
Mich:	Lansing	31	12	0.33	<0.10	<0.16	Oct 65	86	<17
Minn:	Minneapolis	21	10	0.18	<0.10	<0.12	Apr 65	152	<30
Miss:	Jackson	28	6	0.30	<0.10	<0.11	Dec 65	102	<21
Mo:	Jefferson City	31	9	0.22	<0.10	<0.13	Apr 65	129	<26
Mont:	Helena	26	10	0.29	<0.10	<0.14	Sep 65	62	<12
Nebr:	Lincoln	20	4	0.27	<0.10	<0.13	Mar 65	16	<4
Nev:	Las Vegas	30	NS	0.15	<0.10	<0.11	Jun 65		
N. H:	Concord	22	NS	0.31	<0.10	<0.15	Nov 65		
N. J:	Trenton	31	6	0.26	<0.10	<0.13	Dec 65	28	<6
N. Mex:	Santa Fe	29	9	0.13	<0.10	<0.10	Sep 65	50	<10
N. Y:	Albany	22	12	0.25	<0.10	<0.15	Apr 65	73	<15
	Buffalo	29	NS	0.30	<0.10	<0.15	Aug 65		
	New York	30	NS	0.21	<0.10	<0.13	Sep 65		
N. C:	Gastonia	29	10	0.20	<0.10	<0.11	Aug 65	147	<29
N. Dak:	Bismarck	30	6	0.20	<0.10	<0.14	Nov 65	94	<19
Ohio:	Cincinnati	19	NS	0.16	<0.10	<0.10	May 65		
	Columbus	30	10	0.33	<0.10	<0.17	Dec 65	168	<34
	Painesville	24	9	0.29	<0.10	<0.14	Jul 65	53	<11
Okla:	Oklahoma City	25	1	0.18	<0.10	<0.12	Oct 65		
	Ponca City	28	6	0.14	<0.10	<0.10	Jul 65	54	<11
Ore:	Portland	30	5	0.39	<0.10	<0.18	Mar 65	19	<4
Pa:	Harrisburg	30	5	0.20	<0.10	<0.12	Apr 65	75	<15
P. R:	San Juan	26	6	0.10	<0.10	<0.10	Dec 65	136	<27
R. I:	Providence	25	5	0.23	<0.10	<0.13	Oct 65	65	<13
S. C:	Columbia	23	9	0.17	<0.10	<0.11	Sep 65	81	<16
S. Dak:	Pierre	29	NS	0.24	<0.10	<0.14	Jul 65		
Tenn:	Nashville	30	4	0.19	<0.10	<0.12	Oct 65	43	<9
Tex:	Austin	29	2	0.26	<0.10	<0.12	May 65	18	<4
	El Paso	29	4	0.16	<0.10	<0.11	Nov 65	24	<5
Utah:	Salt Lake City	31	6	0.26	<0.10	<0.12	Dec 65	50	<10
Vt:	Barre	29	9	0.23	<0.10	<0.14	Jun 65	97	<20
Va:	Richmond	31	5	0.29	<0.10	<0.13	Jun 65	17	<4
Wash:	Seattle	31	8	0.18	<0.10	<0.10	May 65	39	<8
	Spokane	27	3	0.20	<0.10	<0.12	Apr 65	13	<3
W. Va:	Charleston	30	9	0.20	<0.10	<0.13	Oct 65	53	<11
Wis:	Madison	31	10	0.16	<0.10	<0.11	Jun 65	126	<25
Wyo:	Cheyenne	29	2	0.22	<0.10	<0.12	Jun 65	17	<4
Network summary		1,924	378	0.39	<0.10	<0.12		70	<14

[a] The monthly average is calculated by weighing the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < than values represent more than 10 percent of the average, a less-than sign is placed before the average.

NS, no precipitation sample collected.

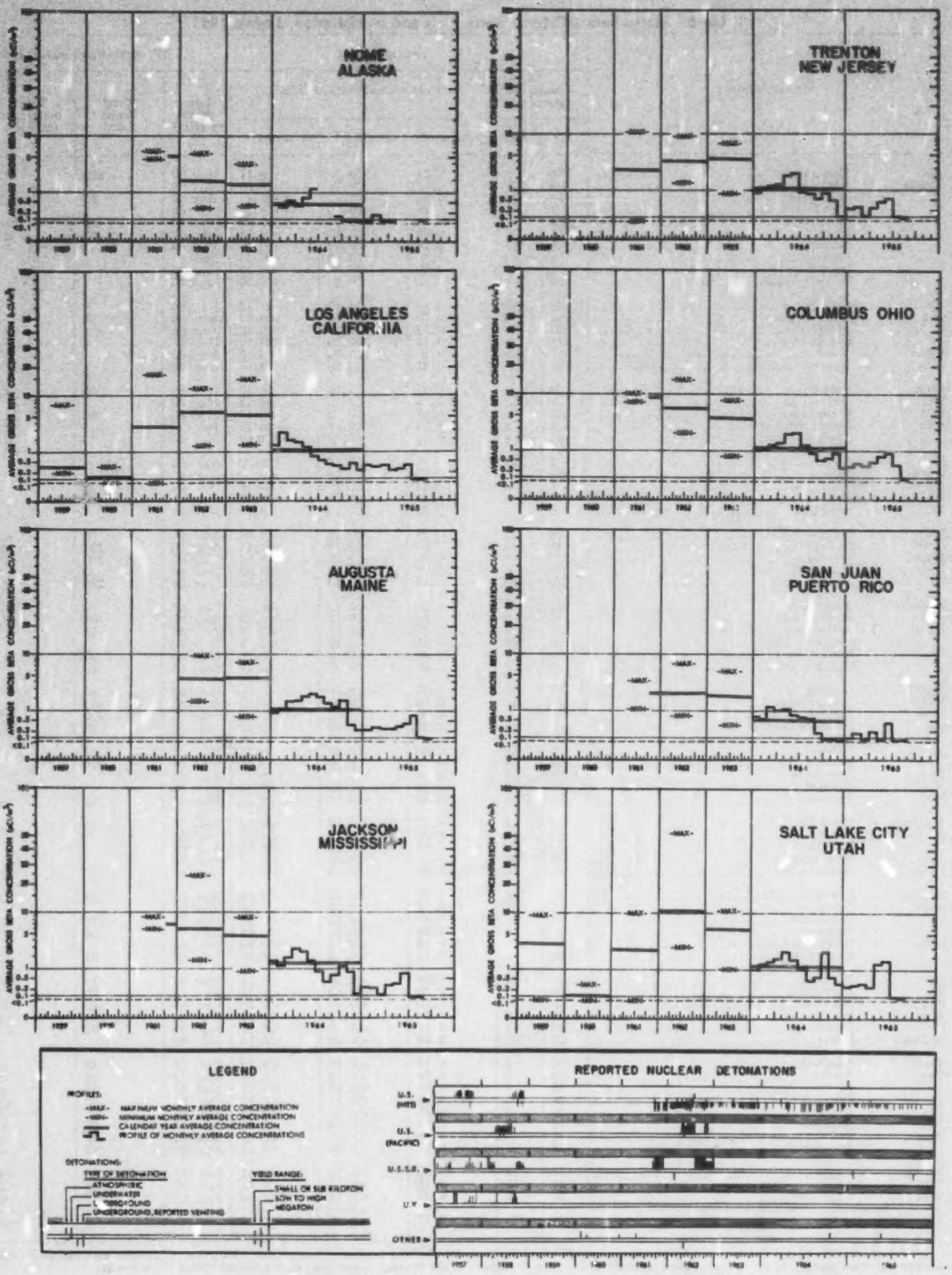

Figure 2. Monthly and yearly profiles of beta activity in air, Radiation Surveillance Network, 1959—August 1965

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2. Canadian Air and Precipitation Monitoring[2] August 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorologic Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*5–10*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa for analysis.

To determine the beta activity, a 2-inch diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a strontium-90—yttrium-90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for August 1965 are given in table 2.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter together with the polyethylene liner is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then

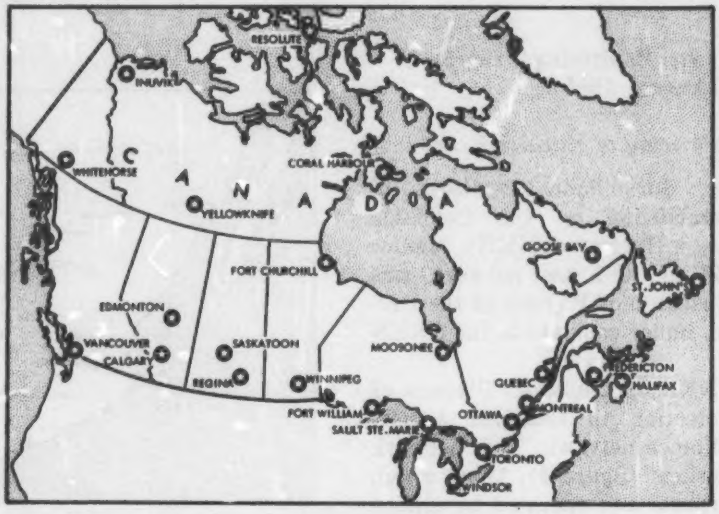

Figure 3. Canadian air and precipitation sampling stations

counted with a thin-end window Geiger-Mueller counter calibrated with a strontium-90—yttrium-90 source. Gross beta activities in precipitation for August 1965 are given in table 2.

---

[2] Prepared from September 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta activity in surface air and precipitation, August 1965

Station	Air surveillance (pCi/m³)				Precipitation measurements	
	Number of samples	Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.3	0.0	0.2	62	4.4
Coral Harbour	29	0.1	0.0	0.0	80	1.7
Edmonton	31	0.2	0.0	0.1	75	4.1
Ft. Churchill	31	0.3	0.0	0.1	138	3.5
Ft. William	31	0.2	0.0	0.1	85	5.5
Fredericton	31	0.3	0.0	0.1	38	4.4
Goose Bay	31	0.2	0.0	0.1	49	4.1
Halifax	31	0.3	0.0	0.1	61	8.0
Inuvik	31	0.3	0.0	0.1	33	3.0
Montreal	31	0.3	0.0	0.1	37	6.0
Moosonee	31	0.2	0.0	0.1	50	5.0
Ottawa	29	0.2	0.0	0.1	65	7.8
Quebec	31	0.2	0.0	0.1	39	7.8
Regina	31	0.3	0.0	0.2	97	2.0
Resolute	31	0.1	0.0	0.0	NS	NS
St. John's, Nfld	28	0.3	0.0	0.1	41	2.2
Saskatoon	31	0.2	0.0	0.1	79	2.3
Sault Ste. Marie	31	0.2	0.0	0.1	69	7.2
Toronto	31	0.4	0.0	0.1	66	4.8
Vancouver	31	0.3	0.0	0.1	65	4.0
Whitehorse	31	0.4	0.0	0.1	93	2.0
Windsor	30	0.4	0.0	0.2	48	3.8
Winnipeg	31	0.2	0.0	0.1	104	3.6
Yellowknife	31	0.2	0.0	0.1	174	2.6
Network summary		0.3	0.0	0.1	70	4.4

NS, no sample.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. The August 1965 gross beta deposition values are given in table 2. Results of radionuclide analyses of deposition are given in table 3. A review and discussion of fallout levels in Canada during 1964 have been presented by Booth *et al.* (*10*).

Table 3. Radionuclide deposition, nCi/m², in Canadian fallout, August 1965[a]

Station	^{90}Sr (nCi/m²)	^{137}Cs (nCi/m²)
Calgary	0.42	0.68
Coral Harbour	0.17	0.35
Edmonton	0.34	0.68
Ft. Churchill	0.38	0.53
Ft. William	0.58	0.86
Fredericton	0.41	0.68
Goose Bay	0.40	0.66
Halifax	0.54	0.90
Inuvik	0.43	0.43
Montreal	0.49	0.79
Moosonee	0.41	0.62
Ottawa	0.70	1.00
Quebec	0.88	1.39
Regina	0.34	0.42
Resolute	NS	NS
St. John's, Nfld	0.33	0.36
Saskatoon	0.14	0.26
Sault Ste. Marie	0.73	0.57
Toronto	0.44	0.86
Vancouver	0.33	0.53
Whitehorse	0.34	0.35
Windsor	0.34	0.50
Winnipeg	0.30	0.42
Yellowknife	0.29	0.34
Network average	0.41	0.60

[a] Samples from all stations are routinely analysed for ^{89}Sr, ^{90}Sr, and ^{137}Cs; samples from five selected stations are regularly analysed for ^{95}Zr and ^{140}Ba. Negligible results are not reported.
NS, no sample.

3. Mexican Air Monitoring Program August 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*11–15*).

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (figure 4), 12 of which are located at airports and operated by airline personnel. The remaining five stations are

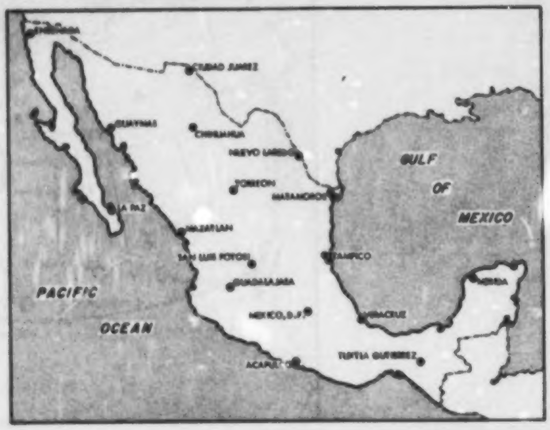

Figure 4. Fallout network sampling stations in Mexico

located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Enseñada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 to 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- × 8-inch glass-fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 to 4 days after collection is allowed for decay of natural radon and thoron daughter radioactivity. Data are not extrapolated back to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during August 1965 are presented in table 4.

Table 4. Gross beta activity of airborne particulates, Mexico, August 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	10	0.2	<0.1	<0.1
Ciudad Juárez	20	0.1	<0.1	<0.1
Chihuahua	20	0.2	<0.1	<0.1
Enseñada	7	<0.1	<0.1	<0.1
Guadalajara	22	0.2	<0.1	<0.1
Guaymas	23	0.1	<0.1	<0.1
La Paz	12	<0.1	<0.1	<0.1
Matamoros	7	<0.1	<0.1	<0.1
Mazatlán	20	0.1	<0.1	<0.1
Mérida	13	<0.1	<0.1	<0.1
México, D.F.	16	0.1	<0.1	<0.1
Nuevo Laredo	16	<0.1	<0.1	<0.1
San Luis Potosí	10	<0.1	<0.1	<0.1
Tampico	18	<0.1	<0.1	<0.1
Torreón	30	0.2	<0.1	<0.1
Tuxtla Gutiérrez	NS			
Veracruz	18	0.1	<0.1	<0.1

NS, no sample collected.

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4. Pan American Air Sampling Program August 1965

Pan American Health Organization, and Public Health Service

Gross beta activity in air is monitored by six countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The six air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; in Trinidad, West Indies, by the University of the West Indies; and in Buenos Aires, Argentina, by the Ministry of Social Welfare and Public Health.

The August 1965 air monitoring results from the six participating countries are given in table 5.

Table 5. Gross beta activity in air, PAHO, August 1965

Sampling stations	Number of samples	Maximum pCi/m³	Minimum pCi/m³	Average [a] pCi/m³
Kingston, Jamaica	14	0.10	<0.10	<0.10
Caracas, Venezuela	20	0.10	<0.10	<0.10
Lima, Peru	22	0.10	<0.10	<0.10
Santiago, Chile	24	0.10	<0.10	<0.10
Trinidad, West Indies	17	0.10	<0.10	<0.10
Buenos Aires, Argentina	NS			

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

NS, no samples analyzed by laboratory.

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DEPOSITION OF FALLOUT CESIUM-137 AT FORT COLLINS, COLORADO, 1962–1964[1]

Daniel W. Wilson, Gerald M. Ward, and James E. Johnson[2]

Analysis of local precipitation for fallout cesium-137 has been carried out routinely since 1962 in connection with a study of the deposition and transfer of cesium-137 to man via the dairy food chain. The Colorado State University Dairy Farm's system of pastures, feed production fields, and dairy herd has been investigated in order to obtain a model for the passage of cesium-137 from deposition on the fields to the soil, cow's milk, and eventually man, and deposition data presented here have been used already for these purposes (*1*).

The precipitation collectors were three fiberglass funnels, each with a 47.2 ft^2 catch area and located 6 feet above ground in the fields of the dairy farm. Precipitation including settled dust and soil was passed by gravity from the funnels through ion exchange columns. Cesium-137 was recovered from the ion exchange resins by elution with 0.5 *M* ammonium nitrate (*2*).

This procedure isolated cesium-137 from other interfering fission products, notably zirconium-niobium-95. The residue that collected at the head of the column often contained clay minerals that fixed cesium-137 irreversibly with respect to ammonium nitrate elution. The cesium-137 content of the precipitation sample was determined from the ammonium nitrate eluate and the residue by gamma scintillation spectrometry (*3*).

The annual depositions of fallout cesium-137 in precipitation and as settled dust were 4.14, 16.0, and 15.8 mCi/mi^2 for 1962 (April through December), 1963, and 1964, respectively. Maximum depositions were coincident with increases in precipitation and ground level air concentrations of cesium-137 that occurred in the late spring and early summer of each year. The daily record of samples, depth of precipitation (inches), and cesium-137 deposition in μCi/mi^2 are given in tables 1–3. Total integrated depositions on a monthly basis are presented in figure 1.

Table 1. Cesium-137 in precipitation in 1962

Date, 1962	Precipitation (inches)	Cesium-137 (μCi/mi^2)
4/26	0.09	ND
4/29	0.42	ND
5/4–7	0.07	243
5/14	0.19	ND
5/16–17	0.29	75
5/17–18	0.31	346
5/20–21	0.12	ND
5/23–25	0.02	46
5/26–27	0.75	445
6/1	0.36	532
6/6	0.33	149
6/16	0.19	199
6/20	0.15	176
6/30	0.50	190
7/8	0.39	512
7/16	0.24	441
7/23	0.34	208
7/26–27	0.40	217
8/1	0.12	30
8/4	0.10	11
8/23	0.11	59
9/8	0.15	42
9/18	0.01	8
9/19–22	0.24	170
10/5–6	1.74	ND
10/15	0.01	ND
11/16–18	0.16	ND
11/18–25	0.17	29
11/29	0.01	ND

ND, nondetectable

Table 2. Cesium-137 in precipitation in 1963

Date, 1963	Precipitation (inches)	Cesium-137 (μCi/mi^2)
1/4	0.06	ND
1/11–18	0.17	ND
1/22–2/1	0.15	16
2/2	0.01	ND
2/8–11	0.05	ND
2/16–3/15	1.31	ND
4/2	0.03	ND
4/7	0.01	ND
4/21	0.04	30
4/26	0.28	ND
4/29	0.01	6
5/16	0.03	326
5/19	0.10	248
5/23	0.20	534
6/3	0.17	1,798
6/8	0.28	1,802
6/14	0.23	631
6/15–16	3.04	3,[illegible]07
6/16	0.03	607
7/4	0.03	346
7/11	0.09	272
7/15	0.03	547
7/18	0.03	280
7/29	0.01	48
8/5	0.13	1,628
8/6	0.18	465
8/9	0.01	118
8/12	0.04	120
8/13	0.09	346
8/15	0.01	70
8/17–18	0.08	295
8/25	0.06	377
8/27	0.26	456
9/10	0.17	294
10/9	0.02	132
10/11	Trace	69
10/20–21	0.37	152
10/21–22	0.16	107
10/26	Trace	16
11/17	0.16	88
11/17–12/31	0.40	345

ND, nondetectable

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[1] This work was supported by Atomic Energy Commission Contract AT (11–1)–1171.

[2] Mr. Wilson is a chemist, Dr. Ward is Professor of Animal Science, and Mr. Johnson is a radiation biologist, Colorado State University.

Table 2. Cesium-137 in precipitation in 1964

Date, 1964	Precipitation (inches)	Cesium-137 (μCi/mi^2)
1/26–27	0.19	185
2/10	0.24	250
2/13	0.08	280
3/26	0.35	315
4/1	0.06	319
4/3	0.33	277
4/20	0.43	1,288
5/7	0.21	2,172
5/26–27	0.33	1,450
5/28–29	0.30	1,304
5/30–31	0.31	1,356
6/1–2	0.13	259
6/8	0.30	1,166
6/21	0.11	940
6/30	0.08	455
7/23	0.05	585
7/29	0.07	922
8/1–2	0.24	623
8/8	0.04	108
8/13	0.12	358
8/16	0.05	363
9/15	0.21	247
9/18–19	0.18	172
10/10–11	0.15	190
10/11–12	Trace	125
11/14	0.30	137

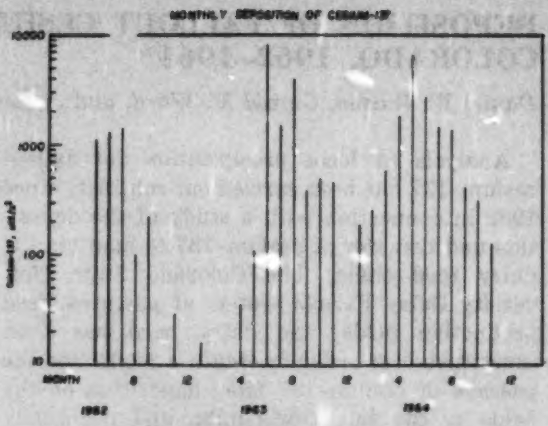

Figure 1. Monthly deposition of cesium-137 at Fort Collins, Colorado, 1962–1964

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, August 1965

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Samples are collected through the cooperation of State and local milk sanitation authorities. According to established procedures, the sample at each station is composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from 1 day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry.[1] After the weekly samples are gamma-scanned, samples from two consecutive weeks are composited and analyzed radiochemically to determine strontium-89 and strontium-90. With all such measurements, there is an inherent statistical variation. For the low radionuclide levels usually observed in milk and other environmental samples, this variation on a percentage basis is relatively high. It depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	less than 100	10	100 or greater	10
Barium-140	less than 100	10	100 or greater	10
Cesium-137	less than 100	10	100 or greater	10
Strontium-89	less than 50	5	50 or greater	10
Strontium-90	less than 20	2	20 or greater	10

[a] Two standard deviations.

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, 10; barium-140, 10; and iodine-131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations determined from the gamma spectrum, but are not reported herein.

Data presentation

Table 2 presents summaries of the analyses for August 1965. Radionuclide concentrations below the minimum detectable level have been averaged using one-half the minimum detectable value. However, since October 1963, iodine-131 and barium-140 averages have been calculated on the basis of zero when concentrations below the minimum detectable level were observed. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in the conterminous United States. The isograms were developed on the basis of extrapolation between the monthly average station values shown.

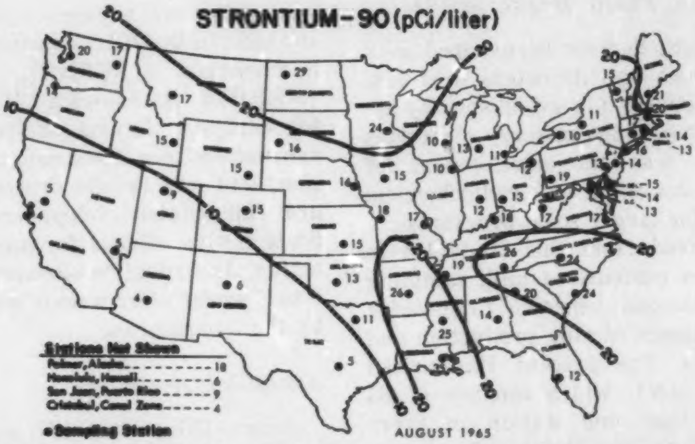

Figure 1. Strontium-90 concentrations in pasteurized milk, August 1965

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk for the second quarter 1965 and August 1965 [a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		Second quarter	August	Second quarter	August	Second quarter	August	Second quarter	August	Second quarter	August
Ala:	Montgomery	1.17	1.17	<5	<5	18	14	55	40	0	0
Alaska:	Palmer	1.22	1.19	<5	<5	20	18	65	40	0	0
Ariz:	Phoenix	1.21	1.21	<5	<5	5	4	20	15	0	0
Ark:	Little Rock	1.15	1.12	5	<5	36	26	70	45	10	0
Calif:	Sacramento	1.35	1.20	<5	<5	8	5	35	25	0	0
	San Francisco	1.36	1.19	<5	<5	11	4	35	25	0	0
C. Z:	Cristobal	1.10	1.06	<5	<5	4	4	35	30	0	0
Colo:	Denver	1.33	1.30	<5	<5	19	15	70	35	0	0
Conn:	Hartford	1.11	1.10	<5	<5	15	13	75	50	0	0
Del:	Wilmington	1.14	1.11	<5	<5	19	15	70	40	0	0
D. C:	Washington	1.18	1.13	5	<5	17	13	55	30	10	0
Fla:	Tampa	1.16	1.16	<5	<5	12	12	175	175	0	0
Ga:	Atlanta	1.15	1.14	<5	<5	29	20	85	55	0	0
Hawaii:	Honolulu	1.23	1.15	<5	<5	10	6	55	40	0	0
Idaho:	Idaho Falls	1.27	1.20	<5	<5	20	15	95	45	10	0
Ill:	Chicago	1.13	1.11	<5	<5	17	10	75	35	10	0
Ind:	Indianapolis	1.15	1.11	5	<5	19	12	55	25	10	0
Iowa;	Des Moines	1.26	1.22	10	<5	23	15	55	30	20	0
Kans:	Wichita	1.25	1.21	<5	<5	18	15	50	25	10	0
Ky:	Louisville	1.15	1.10	5	<5	24	18	45	25	10	0
La:	New Orleans	1.20	1.19	5	<5	42	35	80	65	10	0
Maine:	Portland	1.12	1.10	<5	<5	21	21	125	95	0	0
Md:	Baltimore	1.14	1.10	5	<5	19	14	60	35	10	0
Mass:	Boston	1.13	1.11	<5	<5	22	17	125	85	0	0
Mich:	Detroit	1.13	1.09	<5	<5	17	11	75	35	10	0
	Grand Rapids	1.16	1.13	<5	<5	19	13	80	45	10	0
Minn:	Minneapolis	1.29	1.24	10	<5	28	24	90	50	20	0
Miss:	Jackson	1.18	1.18	5	<5	34	25	55	25	0	0
Mo:	Kansas City	1.25	1.14	10	<5	22	18	45	25	20	0
	St. Louis	1.20	1.23	5	<5	19	17	45	25	20	0
Mont:	Helena	1.28	1.25	<5	<5	20	17	95	60	10	0
Nebr:	Omaha	1.19	1.16	5	<5	21	16	50	30	20	0
Nev:	Las Vegas	1.28	1.26	<5	<5	7	5	40	25	10	0
N. H:	Manchester	1.15	1.12	<5	<5	25	20	150	100	0	0
N. J:	Trenton	1.11	1.09	<5	<5	16	14	70	40	0	0
N. Mex:	Albuquerque	1.23	1.27	<5	<5	10	6	35	20	0	0
N. Y:	Buffalo	1.10	1.11	<5	<5	17	10	95	40	0	0
	New York	1.11	1.09	<5	<5	21	16	90	50	0	0
	Syracuse	1.10	1.09	<5	<5	18	11	80	40	0	0
N. C:	Charlotte	1.20	1.13	5	<5	27	24	65	40	0	0
N. Dak:	Minot	1.25	1.31	10	<5	57	29	120	50	10	0
Ohio:	Cincinnati	1.13	1.10	<5	<5	18	13	50	30	10	0
	Cleveland	1.13	1.10	5	<5	20	12	75	35	10	0
Okla:	Oklahoma City	1.12	1.10	5	<5	20	13	45	25	10	0
Ore:	Portland	1.30	1.21	<5	<5	24	14	90	60	0	0
Pa:	Philadelphia	1.13	1.11	<5	<5	19	13	65	35	0	0
	Pittsburgh	1.14	1.11	5	<5	25	19	95	50	10	0
P. R:	San Juan	1.12	1.13	<5	<5	11	9	50	45	0	0
R. I:	Providence	1.12	1.11	<5	<5	20	14	95	65	0	0
S. C:	Charleston	1.16	1.15	<5	<5	27	24	100	70	0	0
S. Dak:	Rapid City	1.05	NA	10	<5	33	16	105	45	10	0
Tenn:	Chattanooga	1.19	1.16	5	<5	30	26	65	40	0	0
	Memphis	1.15	1.13	5	<5	26	19	45	25	10	0
Tex:	Austin	1.12	1.12	<5	<5	8	5	25	15	0	0
	Dallas	1.17	1.11	5	<5	20	11	45	20	0	0
Utah:	Salt Lake City	1.39	1.43	<5	<5	26	9	120	45	10	0
Vt:	Burlington	1.12	1.10	<5	<5	21	15	100	65	0	0
Va:	Norfolk	1.17	1.13	5	<5	21	17	60	40	10	0
Wash:	Seattle	1.27	1.24	<5	<5	25	20	105	75	0	0
	Spokane	1.30	1.33	<5	<5	27	17	90	50	0	0
W. Va:	Charleston	1.12	1.12	10	<5	20	17	40	20	10	0
Wis:	Milwaukee	1.19	1.14	<5	<5	17	10	85	40	10	0
Wyo:	Laramie	1.23	1.18	5	<5	17	15	70	45	10	0
Network average		1.18	1.16	<5	<5	20.7	15.0	72	44	6	0

[a] All station second quarter averages and all station monthly averages for barium-140 were 0.
NA, no analysis.

The distribution of monthly average strontium-90 and cesium-137 concentrations as observed in pasteurized milk for the months March through August 1965 are presented in tables 3 and 4. The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

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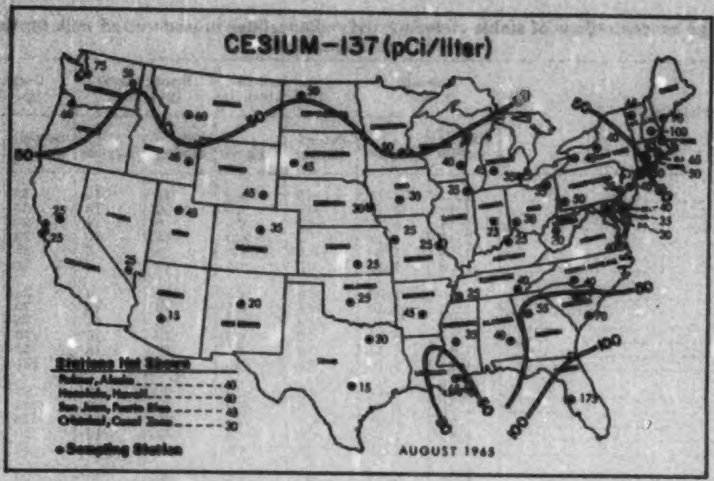
CESIUM-137 (pCi/liter)
Stations Not Shown
Palmer, Alaska 40
Honolulu, Hawaii 40
San Juan, Puerto Rico 45
Cristobal, Canal Zone 30
Sampling Station
AUGUST 1965

Figure 2. Cesium-137 concentrations in pasteurized milk, August 1965

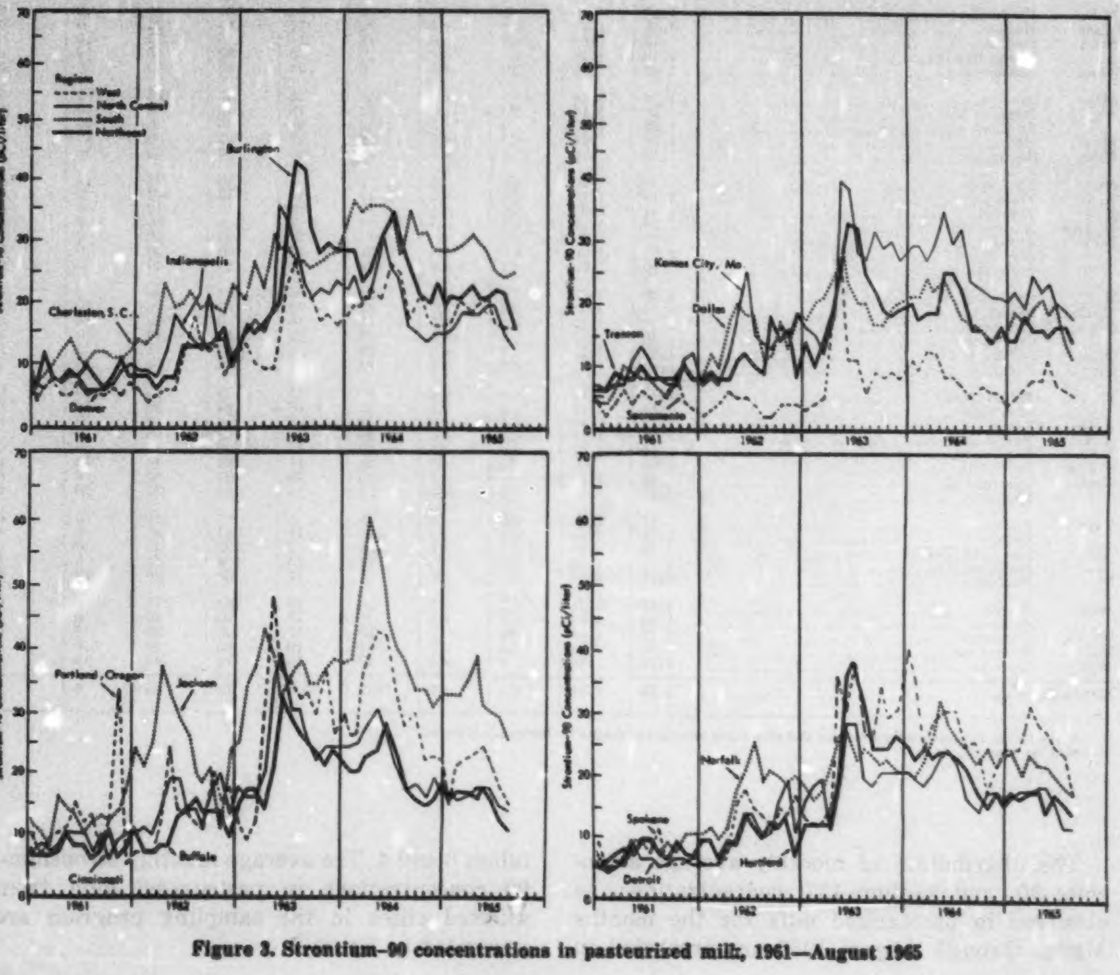

Figure 3. Strontium-90 concentrations in pasteurized milk, 1961—August 1965

Table 3. Frequency distribution, strontium-90 concentrations in milk at PMN stations, March–August 1965 and August 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	Mar	Apr	May	June	July	Aug	Aug
Under 10	5	5	4	7	8	10	7
10–19	29	23	26	21	34	41	23
20–29	21	27	25	29	18	11	23
30–39	6	5	5	4	3	1	6
40–49	1	2	2	2	0	0	4
50–59	1	0	0	0	0	0	0
60–69	0	1	1	0	0	0	0
70–79	0	0	0	0	0	0	0

Table 4. Frequency distribution, cesium-137 concentrations in milk at PMN stations, March–August 1965, and August 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	Mar	Apr	May	June	July	Aug	Aug
Under 50	9	7	17	19	34	45	6
50–99	36	35	31	38	25	16	30
100–149	16	18	13	5	3	1	19
150–199	2	3	2	1	1	1	6
200–249	0	0	0	0	0	0	1
250–299	0	0	0	0	0	0	1

2. California Milk Network[1]
April–June 1965

Bureau of Radiological Health
California State Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

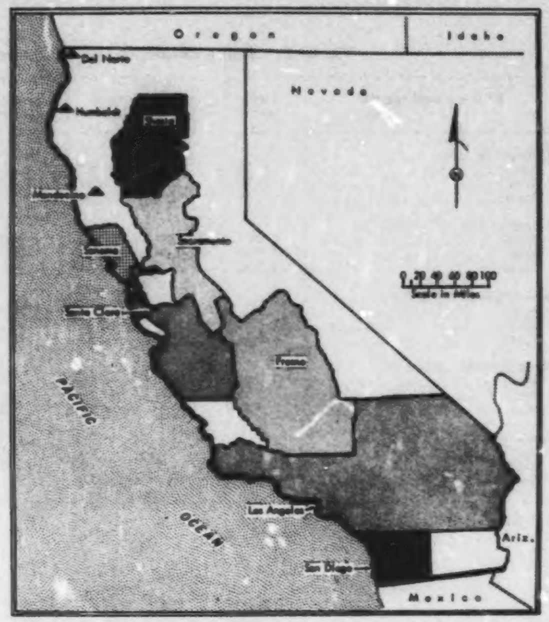

Figure 4. California milksheds

Analytical procedures

After precipitation of the proteins with trichloroacetic acid, strontium is precipitated, scavenged, and beta counted in a low-background counter. After a 2-week ingrowth period, the yttrium-90 is precipitated from the radiostrontium fraction and beta counted. Strontium-90 is determined from the yttrium-90 results; strontium-89 is determined as the difference between total radiostrontium and strontium-90.

Potassium-40, iodine-131, cesium-137 and barium-140 in whole fluid milk are determined by gamma-scintillation spectroscopy using a sodium iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium-40 concentration (pCi/liter) by 1.18×10^{-3}. A more complete description of the laboratory equipment and procedures was published earlier (*2*).

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[1] This work was summarized under the supervision of Amasa C. Cornish, Senior Health Physicist, Jack L. Brown, Associate Health Physicist, and George Barr, Radiological Health Specialist, Bureau of Radiological Health, California State Department of Public Health.

Results

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 5 for the period April to June 1965. As has been previously noted, the Del Norte sample differs significantly from the network average. The appearance of strontium-89 in Shasta and Sonoma counties was not to be expected in light of the previous six months' results. The sudden appearance of this radionuclide, along with increases in strontium-90 and cesium-137, indicates the influx of fresh fission products during this period. A description of the various California milksheds was presented earlier by Heslep and Cornish (*3*).

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 5. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963. This peak resulted from 1961 and 1962 atmospheric nuclear testing. This downward trend can be expected to continue with the cessation of atmospheric nuclear testing.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1963	*March 1964*
October–December 1963	*June 1964*
January–March 1964	*September 1964*
April–June 1964	*December 1964*
July–September 1964	*March 1965*
October–December 1964	*June 1965*
January–March 1965	*September 1965*

Table 5. Stable elements and radionuclides in California milk, April–June 1965

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
April	1.39	1.19	1.25	1.18	1.12	1.26	1.10	1.11	1.17	1.28	1.21
May	1.59	1.36	1.24	1.23	1.33	1.38	1.29	1.28	1.16	1.42	1.33
June	1.39	1.20	1.26	1.04	1.26	1.16	1.12	1.26	NA	1.23	1.21
Potassium-40 (pCi/liter)											
April	1,200	1,160	1,140	1,190	1,250	1,170	1,180	1,190	1,230	1,210	1,190
May	1,200	1,180	1,170	1,260	1,290	1,240	1,330	1,230	1,160	1,250	1,230
June	1,200	1,160	1,150	1,140	1,260	1,210	1,150	1,290	1,160	1,260	1,200
Strontium-89 (pCi/liter)											
April	ND	ND	ND	ND	ND	ND	ND	NA	4.2	4.7	0.9
May	ND	ND	ND	ND	ND	ND	ND	NA	3.7	ND	0.4
June	ND	ND	ND	ND	ND	ND	ND	NA	NA	1.0	0.4
Strontium-90 (pCi/liter)											
April	40	13	15	4	22	6	4	8	15	14	14
May	51	7	19	4	11	10	5	5	13	13	14
June	33	6	14	3	6	6	3	6	NA	8	9
Cesium-137 (pCi/liter)											
April	116	38	53	34	94	71	23	31	71	79	61
May	110	49	43	28	59	48	24	32	65	32	49
June	57	43	28	14	14	33	20	38	45	29	32

Key to symbols: NA, no analysis performed
ND, below detectable levels.

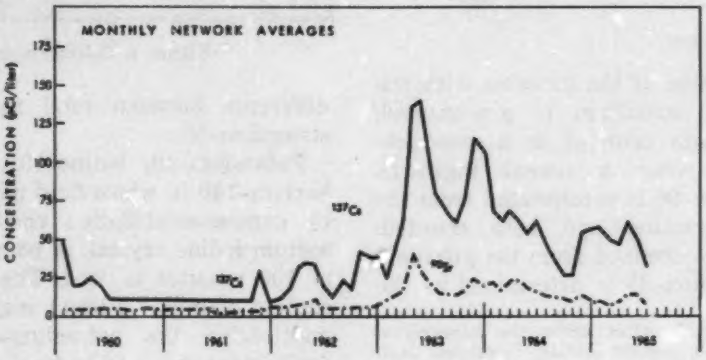

Figure 5. Radionuclides in California pasteurized milk, 1960–June 1965

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3. Oregon Milk Network, April–June 1965

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored the concentrations of radionuclides in milk throughout Oregon on a continuing basis since the initiation of the milk surveillance program in March 1962. Milk samples are routinely collected at eight major production areas (figure 6), which supply 90 percent of the milk distributed in the State.

Half-gallon samples of pasteurized packaged milk are collected monthly from milk producing plants located in the eight milk producing areas Statewide by Oregon's Department of Agriculture. The Portland milk producing area samples are collected weekly by the city of Portland. The Portland milk district sample is also analyzed as part of the USPHS Pasteurized Milk Network on a weekly basis, with the results serving as a continuing interlaboratory reference. The milk sampling frequency is accelerated to a weekly basis in areas where iodine–131 concentrations exceed 100 pCi/liter, or where cesium–137 concentrations exceed 500 pCi/liter. The strontium–90 analyses are usually performed on a bimonthly schedule, but may be done monthly when significant increases are observed.

Analytical procedures

All milk samples are forwarded to and analyzed by the Oregon State Board of Health Environmental Radiation Laboratory. The concentrations of cesium–137, iodine–131, and barium–140 are determined by gamma spectrometry. The strontium–90 concentrations are determined using a trichloroacetic acid analytical procedure (4), with the counting performed by means of a low-background counting system that includes a 2¼-inch detector.

The minimum detectable limits for determining the concentrations of the radionuclides, cesium–137, iodine–131, and barium–140 are 15 pCi/liter; the limit for strontium–90 is 2 pCi/liter. The minimum detectable concentration is defined as the activity which is three times the standard deviation of the observed background activity.

Results and discussion

Cesium–137 concentrations in Oregon pasteurized milk (table 6) remained relatively constant at most of the sampling locations during April through June 1965.

Strontium–90 concentrations remained relatively constant in comparison with the previous period. Iodine–131 and barium–140 concentrations remained below the minimum detectable limit of 15 pCi/liter. The results for April through June 1965 appear in table 6.

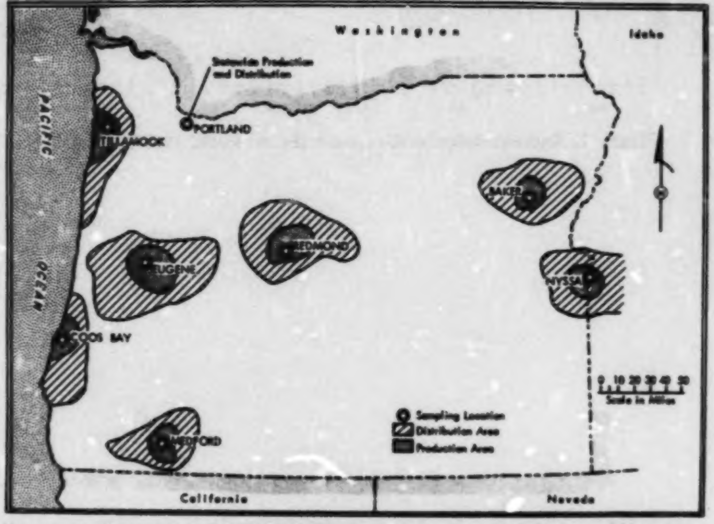

Figure 6. Oregon pasteurized milk network sampling locations showing production and distribution areas

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[1] This work was summarized under the supervision of George L. Toombs, Chief Radiochemist, Oregon State Board of Health.

Table 6. Radionuclide concentrations in Oregon milk, April—June 1965

Sampling location	Sampling frequency	Strontium-90, (pCi/liter)			Cesium-137, (pCi/liter)		
		April	May	June	April	May	June
Albany	BM	NA	NS	NA	100	NS	75
Baker	M	NA	17	NA	80	80	80
Coos Bay	M	NA	31	NS	140	140	45
Corvallis	BM	NA	NS	NA	80	NS	80
Eugene	M	NA	14	NA	75	85	55
Medford	M	NA	13	NA	85	80	55
Nyssa	M	NA	15	NA	65	80	80
Portland composite	W	21	27	NA	90	85	90
Portland local	W	NA	25	NA	120	100	90
Redmond	M	NA	13	NA	55	75	70
Tillamook	M	NA	35	NA	120	125	265
Average	—	21	24	—	90	90	90

Key to symbols: BM, sampled bimonthly
M, sampled monthly
W, sampled weekly
NS, no sample collected
NA, no analysis

Additional samples were collected on April 19, 1965, from the Redmond and Baker milk districts following the reported venting of an underground nuclear test on April 14, 1965, at the Nevada Test Site (*5*). No significant changes in the concentrations of the radionuclides were detected in these samples in comparison with previous and prior data at these locations.

General trends for the levels of strontium-90 and cesium-137 can be observed from the concentrations representing the monthly network averages presented graphically in figure 7. The peak concentrations experienced in the spring of 1963 have shown a continual decrease, except for seasonal variations. This general trend can be expected to continue with the prolonged cessation of atmospheric nuclear testing.

The radionuclide concentrations in Oregon milk remain low in comparison to the recommendations of the Federal Radiation Council for remedial action based on health implications.

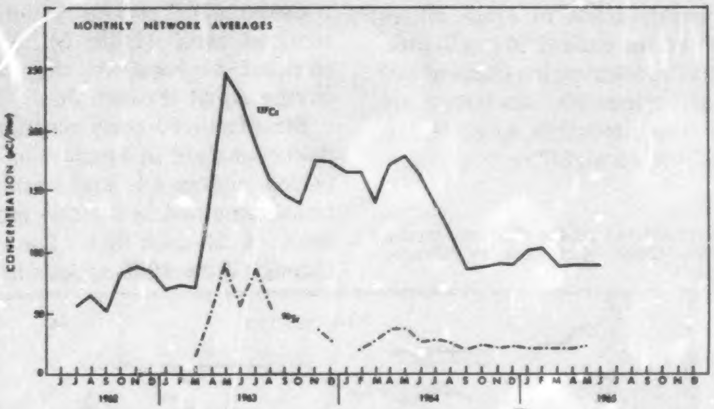

Figure 7. Radionuclides in Oregon milk network, 1962–June 1965

4. Canadian Milk Network[3]
August 1965

Radiation Protection Division,
Department of National Health and
Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (figure 8) can be chosen in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–37, and strontium–90, as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical methods

Since it represents a more sensitive method, radiochemistry, rather than gamma spectrometry, is used to determine iodine–131 (*6*). For the analysis of radiostrontium, carrier strontium is added to a 1-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle furnace at 450°C. and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter.

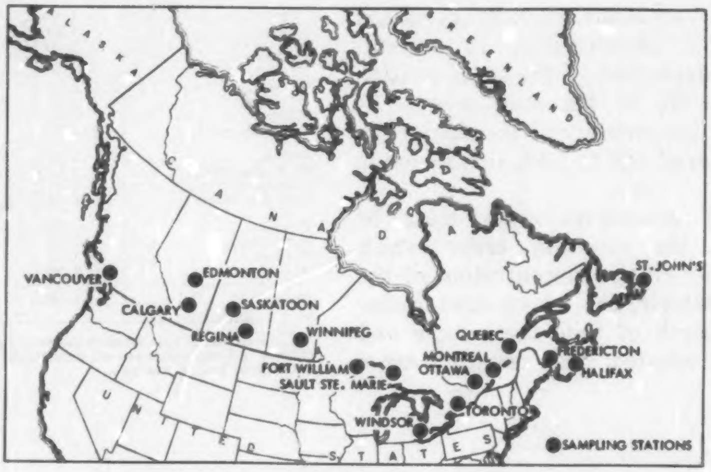

Figure 8. Canadian milk sampling stations

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[3] Prepared from information and data in the September 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectrometry using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- × 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radionuclide in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137, this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated methematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 7.

Table 7. Total error for various radionuclide concentrations in milk [a]

Nuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 8 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

Table 8. Radionuclides in Canadian whole milk, August 1965 [a]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.17	1.5	19.5	50
Edmonton	1.11	1.7	20.2	96
Ft. William	1.00	1.6	25.7	115
Fredericton	1.00	1.6	28.9	152
Halifax	1.11	1.5	27.7	108
Montreal	1.04	1.6	18.9	50
Ottawa	1.13	1.8	11.7	34
Quebec	1.07	1.7	16.7	110
Regina	1.05	1.5	17.1	58
St. John's, Nfld	1.04	1.4	51.2	244
Saskatoon	1.11	1.4	34.8	59
Sault Ste. Marie	1.08	1.8	22.8	106
Toronto	1.05	1.6	7.0	52
Vancouver	1.15	[b]	17.4	[b]
Windsor	1.11	1.6	6.9	19
Winnipeg	1.00	1.8	17.7	72
Average	1.08	1.6	21.6	88

[a] Due to insignificant levels of iodine-131 and strontium-89, the reporting of these radionuclides has been discontinued.

[b] Sample lost in analysis.

5. Pan American Milk Sampling Program August 1965

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963, this was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, milk stations were added in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde, and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas; Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma scintillation spectrometry. Strontium–89, strontium–90, and barium–140 are determined radiochemically (*7*). Analytical errors are discussed in the "Analytical Procedures, Pasteurized Milk Network," page 677.

Data presentation

Table 9 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations. The monthly average of iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

Table 9. Stable element and radionuclide concentrations in PAHO milk, August 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.08	1.4	<5	4	30
Jamaica:					
Kingston	NS				
Mandeville	NS				
Montego Bay	1.20	1.3	<5	17	300
Puerto Rico:					
San Juan	1.13	1.6	<5	9	45
Venezuela:					
Caracas	1.19	1.5	<5	3	15

NS, no sample.

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(*1*) PUBLIC HEALTH SERVICE. Summary of results from the raw milk sampling program, June 1957–April 1963. Rad Health Data 4:511–523 (October 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960–June 1962. Rad Health Data 4:90–92 (February 1963).

(*3*) HESLEP, J. M., and A. C. CORNISH. California milk network and milkshed comparisons, April–June 1963. Rad Health Data 4:596–599 (December 1963).

(*4*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium–90 determinations in milk. J Dairy Sci 43:151–154 (1960).

(*5*) PUBLIC HEALTH SERVICE. Reported Nuclear Detonations, April 1965. Rad Health Data 6:289 (May 1965).

(*6*) DASGUPTA, A. K., and H. G. GREEN. A method for the radiochemical determination of iodine–131 in milk. RPD–28, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

(*7*) PORTER, C., and B. KAHN. Improved determinations of strontium–90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK TO INTAKE GUIDES, SEPTEMBER 1964—AUGUST 1965

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3–4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 grams of calcium per liter in PMN samples and a 1.0 gram daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pCi/day) of radio-

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of nonmilk products whose contamination reflects temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

Table 1. Average radionuclide concentrations in milk (pCi/liter) for the 12-month periods,[a] August 1964–July 1965 and September 1964–August 1965

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Aug 1964–July 1965	Sept 1964–Aug 1965	Aug 1964–July 1965	Sept 1964–Aug 1965	Aug 1964–July 1965	Sept 1964–Aug 1965	Aug 1964–July 1965	Sept 1964–Aug 1965
Ala:	Montgomery	3	3	19	18	0	0	53	51
Alaska:	Palmer	3	3	17	18	1	1	73	67
Ariz:	Phoenix	3	3	5	5	0	0	34	23
Ark:	Little Rock	5	5	35	34	2	2	68	65
Calif:	Sacramento	3	3	7	7	1	1	30	30
	San Francisco	3	3	8	8	0	0	31	30
C. Z:	Cristobal	3	3	5	5	0	0	42	40
Colo:	Denver	3	3	18	18	1	1	71	65
Conn:	Hartford	3	3	17	17	0	0	85	80
Del:	Wilmington	3	3	18	18	2	2	71	67
D. C:	Washington	3	3	17	16	2	2	53	51
Fla:	Tampa	3	3	13	13	0	0	194	187
Ga:	Atlanta	3	3	26	25	1	1	86	82
Hawaii:	Honolulu	3	3	11	10	0	0	64	61
Idaho:	Idaho Falls	3	3	30	30	2	2	93	88
Ill:	Chicago	3	3	16	15	2	2	75	71
Ind:	Indianapolis	3	3	16	16	4	4	60	56
Iowa:	Des Moines	4	5	22	21	6	6	58	53
Kans:	Wichita	3	3	18	18	2	2	46	44
Ky:	Louisville	4	4	23	22	2	2	47	45
La:	New Orleans	5	5	41	40	2	2	83	78
Maine:	Portland	3	3	23	23	2	2	137	130
Md:	Baltimore	3	3	18	18	2	2	58	56
Mass:	Boston	3	3	23	22	0	0	133	123
Mich:	Detroit	3	3	15	15	3	3	75	70
	Grand Rapids	3	3	18	18	2	2	84	80
Minn:	Minneapolis	7	7	26	26	5	6	86	81
Miss:	Jackson	3	3	33	32	1	1	60	55
Mo:	Kansas City	5	5	22	21	8	8	47	45
	St. Louis	4	4	17	17	4	4	45	42
Mont:	Helena	3	3	18	18	3	3	92	88
Nebr:	Omaha	3	3	20	19	4	4	56	52
Nev:	Las Vegas	3	3	7	7	2	2	42	40
N. H:	Manchester	3	3	25	24	1	1	154	145
N. J:	Trenton	3	3	16	15	1	1	72	68
N. Mex:	Albuquerque	2	2	9	9	1	1	39	37
N. Y:	Buffalo	3	3	16	15	0	0	93	88
	New York	3	3	20	19	2	2	95	89
	Syracuse	3	3	16	16	1	1	82	79
N. C:	Charlotte	3	3	30	29	1	1	60	62
N. Dak:	Minot	7	6	47	46	2	2	115	109
Ohio:	Cincinnati	3	3	17	17	2	2	55	53
	Cleveland	4	4	18	17	2	2	76	72
Okla:	Oklahoma City	4	5	19	18	2	2	46	44
Ore:	Portland	3	3	23	21	0	0	96	88
Pa:	Philadelphia	3	3	17	16	0	0	68	65
	Pittsburgh	4	4	24	23	2	2	94	88
P. R:	San Juan	3	3	11	11	1	1	53	51
R. I:	Providence	3	3	19	19	0	0	102	95
S. C:	Charleston	3	3	29	28	1	1	95	90
S. Dak:	Rapid City	7	7	30	28	4	4	110	105
Tenn:	Chattanooga	4	4	32	31	1	1	67	62
	Memphis	4	4	25	24	2	2	44	41
Tex:	Austin	3	3	8	7	2	2	29	28
	Dallas	3	3	17	17	1	1	40	38
Utah:	Salt Lake City	3	3	23	21	2	2	117	106
Vt:	Burlington	3	3	21	20	2	2	111	103
Va:	Norfolk	4	4	16	15	3	3	60	58
Wash:	Seattle	3	3	23	22	0	0	104	95
	Spokane	3	3	25	24	0	0	97	91
W. Va:	Charleston	4	4	19	18	2	2	43	40
Wis:	Milwaukee	3	3	14	14	3	3	85	81
Wyo:	Laramie	3	3	15	15	2	2	71	65
Network average		3	3	19.6	19.0	2	2	75	70

[a] Annual averages for barium-140 at each station were <2 pCi/liter

nuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous 12-month average by 1 month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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SUMMARY OF RESULTS OF INSTITUTIONAL TOTAL DIET SAMPLING NETWORK, 1961-1964

R. D. Grundy[1], *C. Calvert*[2], *A. G. Berger*[3]

The results of monthly radionuclide analyses of Institutional Diet Samples are periodically reported in *Radiological Health Data.* A discussion of the network's objectives and sample collection and analytical procedures appears elsewhere (*1, 2*).

Approximately 21 institutions have cooperated in the study from 1961 through 1964. Each monthly sample consists of 21 meals plus snacks, collected during one week in the month. Drinking water is not included in the sample. Under the sampling protocol, a different individual was chosen each day of the sampling week and his diet for that day was duplicated for inclusion in the sample. The resultant weekly sample consists of the combined daily meals of seven individuals. In some cases less than 21 meals were eaten during the sampling period. Where the missing meals were not eaten at the institution or elsewhere the sample was assumed to be complete. Where missing meals were eaten elsewhere, the daily intakes were adjusted to account for unsampled meals.

Where it was necessary to discontinue sample collection at an institution in a particular city, sample collection was later begun at another institution in the same city. It was not possible to collect representative samples from children of all ages and both sexes each month at an institution. Variations in types and quantities of food consumed by individuals or groups made it necessary to consider types and quantities of food consumed in terms of mean values and deviations.

The primary purpose of the program is to measure the radionuclide concentrations in the diet and variations in radionuclide intake with time. Analyses were made for strontium-89, strontium-90, radium-226 (or total radium), cesium-137, barium-140, and iodine-131. To assist in the evaluation of these results, average daily intakes were determined for each sampling period, along with calcium, phosphorus and potassium concentrations.

The population group sampled consisted of children in boarding schools and institutions. As is customary in such establishments, efforts are made to supply an adequate nutritive diet based upon standard portions. In such circumstances (standard portions), the sampling of seven daily intakes at a given institution for a given month may be assumed as reasonably representative of the institution. Since the institutions have been selected to arbitrarily represent major metropolitan areas, it is possible to discuss intake values only on a nationwide basis in terms of distributions and ranges. Future extrapolation to children in the general population will be investigated when additional data regarding individual food consumption (based on probability sampling) become available. This summary is concerned with the trends in radionuclide intakes as reflected in institutional diet program yearly averages at each station, and network monthly averages, maxima, and minima, from 1961 through 1964.

Intakes

Table 1 presents the annual averages of monthly diet and nuclide intakes for each of 21 institutions.[4] These results are based on the 21 institutions which have provided monthly samples since 1961.

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[1] Chief, Environmental Data Unit, Data Collation and Analysis Section, Radiation Surveillance Center, DRH, PHS, Washington, D.C.

[2] Project Officer, Technical Operations Branch, DRH.

[3] Chief, Demographic and Sampling Quality Control Staff, Radiation Surveillance Center, DRH.

[4] Based upon monthly values previously published in *Radiological Health Data.*

Table 1. Average annual institutional

	Year	Alaska, Palmer	California, Los Angeles	Colorado, Denver	Florida, Tampa	Georgia, Atlanta	Hawaii, Honolulu	Illinois, Chicago	Louisiana, New Orleans	Massachusetts, Boston	Minnesota, Minneapolis	Missouri, St. Louis
Number of samples	1961	3	11	12	2	10	2	5	—	2	—	9
	1962	12	7	11	9	12	11	6	12	12	12	6
	1963	12	9	11	12	12	11	6	12	12	12	9
	1964	12	9	12	12	10	10	12	12	12	9	12
Total weight (kg/day)	1961	1.91	1.60	2.06	1.84	1.56	2.11	1.63	—	2.16	—	2.37
	1962	1.48	1.40	2.02	1.66	1.63	1.93	1.54	2.22	1.90	1.61	3.00
	1963	1.51	1.83	2.19	1.97	1.63	1.74	1.64	2.28	1.74	1.74	2.53
	1964	1.50	1.79	2.42	2.16	2.01	1.71	1.57	2.58	1.69	1.74	2.43
Calcium (g/day)	1961	0.7	1.0	1.7	1.2	0.8	0.6	1.0	—	1.1	—	1.2
	1962	1.0	0.8	1.6	0.9	1.4	0.8	0.9	1.4	1.3	0.9	1.9
	1963	0.8	1.0	1.3	1.2	0.8	0.7	1.1	1.5	1.3	0.7	1.6
	1964	0.8	1.2	1.5	1.5	1.0	0.8	1.1	1.6	1.2	0.9	1.6
Phosphorus as phosphate (g/day)	1961	3.7	4.4	5.7	4.9	3.5	4.0	4.3	—	5.5	—	6.4
	1962	3.7	3.3	6.2	3.7	3.7	3.5	2.9	5.2	4.5	3.6	7.4
	1963	3.1	4.3	4.2	4.4	3.6	3.1	3.4	5.7	3.7	2.9	6.1
	1964	—	—	—	—	—	—	—	—	—	—	—
Potassium (g/day)	1961	2.9	2.1	2.8	2.4	2.1	3.1	2.5	—	3.1	—	3.1
	1962	2.5	2.3	3.8	2.2	2.0	2.4	3.5	3.1	3.5	2.0	5.4
	1963	2.7	2.9	3.6	2.6	1.8	2.5	2.6	3.4	2.8	2.7	4.4
	1964	2.1	2.8	3.7	2.6	2.3	2.3	2.4	3.5	2.6	2.5	3.4
Total radium (pCi/day)	1961	4.9	5.4	7.1	7.8	5.1	14.5	7.4	—	9.0	—	7.2
	1962	1.8	1.7	5.3	2.5	2.5	6.1	1.7	2.8	2.6	1.9	6.2
	1963	[a]	[a]	[b]	4.3	3.6	[a]	[a]	4.6	[a]	[b]	[b]
Radium-226	1964	1	1	2	[a] 4.3	[a] 3.4	2	1	[a] 6.3	1	1	2
Strontium-89 (pCi/day)	1961	—	—	—	17	7	—	11	—	45	—	—
	1962	42	10	66	11	48	17	13	120	18	60	152
	1963	18	12	24	38	54	35	19	182	15	27	62
	1964	10	5	10	5	10	10	5	10	5	10	15
Strontium-90 (pCi/day)	1961	5	5	7	10	7	5	7	—	16	—	8
	1962	12	4	19	10	12	8	5	29	11	13	25
	1963	19	9	25	22	23	11	39	46	34	17	35
	1964	30	17	31	29	38	18	21	67	34	32	48
Cesium-137 (pCi/day)	1961	46	11	25	134	13	32	14	—	20	—	22
	1962	42	11	70	43	34	30	70	77	96	50	52
	1963	140	74	137	268	112	97	153	221	228	128	194
	1964	155	90	150	295	120	125	140	225	260	145	150
Barium-140 (pCi/day)	1961	27	16	20	19	16	27	16	—	21	—	23
	1962	21	16	27	20	19	30	12	26	17	36	60
	1963	10	10	10	25	24	10	15	29	15	10	10
	1964	0	0	0	0	0	0	0	0	0	0	0
Iodine-131 (pCi/day)	1961	19	6	11	22	27	42	38	—	85	—	6
	1962	49	12	22	20	22	36	14	29	18	26	25
	1963	15	15	10	25	24	10	15	29	15	12	10
	1964	0	0	0	0	0	0	0	0	0	0	0

Dash indicates no analysis.

[a] Total radium reported for January—August 1963; radium-226 reported the remainder of the year. Monthly averages for total radium ranged from <1-12 during the period from January—August. Monthly averages for radium-226 ranged <1-5 during the remainder of the year.

[b] Total radium reported for January—July 1963; radium-226 reported the remainder of the year. Monthly averages for total radium ranged from <1-3 during the period from January—July 1963. Monthly averages for radium-226 ranged from <1-4 during the remainder of the year.

A frequency distribution of dietary intake was developed for each year (table 2). Over the 4-year period the average dietary intake was 1.90 kg/day (figure 1). The distribution approaches that of a normal distribution and has a standard deviation of 0.43 kg/day. It is noted that the individual yearly average intakes were within 3 percent of the 4-year average.

Table 2. Frequency distribution of annual average dietary intake, 1961–1964

Range (kg/day)	Number of stations				Total	
	1961	1962	1963	1964	Number	Percent
1.30–1.59	2	8	4	3	17	22
1.60–1.89	3	5	10	6	24	31
1.90–2.19	5	3	2	7	17	22
2.20–2.49	3	1	4	4	12	16
2.50–2.79	1	2	1	1	5	6
2.80–3.09		2			2	3
Total	14	21	21	21	77	100
Average	1.96	1.88	1.84	1.92	—	—

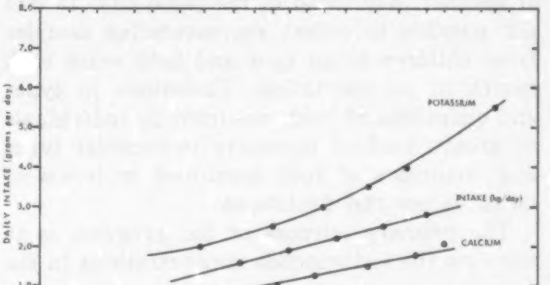


Figure 1. Cumulative frequency distribution of daily dietary, calcium, and potassium intakes

daily dietary intake, 1961–1964

Montana, Helena	Nebraska, Omaha	New Mexico, Albuquerque	New York, New York	Ohio, Cleveland	Tennessee, Memphis	Texas, Austin	Utah, Salt Lake City	Virginia, Norfolk	Washington, Seattle	All institutions average	Year	
—	—	—	10	—	3	11	2	—	11		1961	Number of samples.
10	11	12	6	12	12	12	9	12	12		1962	
12	11	11	8	12	12	12	9	12	12		1963	
12	12	12	4	12	12	12	10	12	12		1964	
—	—	—	1.35	—	1.95	2.47	2.13	—	2.29	1.96	1961	Total weight (kg/day).
2.46	1.71	1.56	1.45	1.75	1.59	2.66	1.43	1.48	2.80	1.88	1962	
1.51	1.82	1.71	1.69	1.89	1.60	2.32	1.48	1.55	2.37	1.84	1963	
2.03	2.03	1.92	1.74	1.95	1.60	1.95	1.42	2.19	1.90	1.92	1964	
—	—	—	0.7	—	1.2	1.5	0.8	—	1.5	1.1	1961	Calcium (g/day).
1.5	1.1	1.1	0.7	1.2	0.9	1.5	0.9	0.7	2.1	1.2	1962	
0.8	1.2	1.3	1.5	1.4	1.1	1.3	0.9	0.8	1.4	1.1	1963	
1.0	1.6	1.6	1.4	1.2	1.0	1.0	0.9	1.1	1.2	1.2	1964	
—	—	—	2.9	—	4.3	6.1	4.4	—	6.4	4.8	1961	Phosphorus as phosphate (g/day).
5.8	4.3	4.1	2.7	4.1	3.5	6.3	3.1	3.3	6.9	4.4	1962	
3.1	3.9	4.0	4.0	5.3	3.6	5.8	3.2	3.5	5.5	4.1	1963	
—	—	—	—	—	—	—	—	—	—	—	1964	
—	—	—	2.0	—	2.8	3.2	3.1	—	3.0	2.7	1961	Potassium (g/day)
3.5	2.7	2.6	2.5	3.8	2.5	2.7	2.3	1.9	4.6	3.0	1962	
2.4	3.1	2.9	3.0	3.3	2.4	3.0	2.7	2.0	3.6	2.9	1963	
2.4	2.9	2.9	2.8	3.2	2.0	2.1	2.2	2.4	2.8	2.7	1964	
—	—	—	3.7	—	8.9	9.5	10.1	—	7.7	7.7	1961	Total radium (pCi/day).
3.9	2.4	1.7	2.4	2.5	2.2	2.6	2.4	2.4	6.1	3.0	1962	
[a]	[a]	[a]	[a]	[a]	2.9	3.9	[a]	2.7	[a]	[b]	1963	
1	2	1	1	1	[c] 3.0	2.9	1	[c] 4.3	1	[b]	1964	Radium-226.
—	—	—	2	—	105	18	—	—	—	29	1961	Strontium-89 (pCi/day).
67	35	18	8	11	59	57	38	63	105	48	1962	
21	38	18	12	16	72	71	15	42	72	41	1963	
10	5	5	0	5	5	5	5	10	10	7	1964	
—	—	—	6	—	13	10	7	—	7	8	1961	Strontium-90 (pCi/day).
13	9	5	5	7	14	16	7	13	27	13	1962	
17	25	12	27	35	27	26	13	21	32	25	1963	
30	39	24	27	26	32	20	26	34	43	32	1964	
—	—	—	16	—	15	14	15	—	34	29	1961	Cesium-137 (pCi/day).
56	24	17	20	67	17	69	38	29	100	49	1962	
126	125	44	131	135	90	108	130	81	215	140	1963	
190	140	80	170	170	80	70	155	130	200	154	1964	
—	—	—	13	—	20	25	21	—	26	21	1961	Barium-140 (pCi/day).
73	17	30	14	15	20	29	17	18	39	27	1962	
10	15	10	13	14	23	20	18	23	22	16	1963	
0	0	0	0	0	0	0	0	0	0	0	1964	
—	—	—	5	—	53	14	34	—	22	27	1961	Iodine-131 (pCi/day).
24	23	55	14	19	21	35	15	17	40	25	1962	
10	10	10	13	15	23	29	10	23	14	16	1963	
0	0	0	0	0	0	0	0	0	0	0	1964	

[a] Total radium reported for January—June 1963; radium-226 reported the remainder of the year. Monthly averages for total radium were <1 from the period from January—June 1963. Monthly averages for radium-226 ranged from <1–2 during the remainder of the year.

[b] Average for all institutions is not given since total radium was reported for a number of institutions for part of the year and radium-226 for the remainder of the year.

[c] Average represents total radium since radium-226 was not determined.

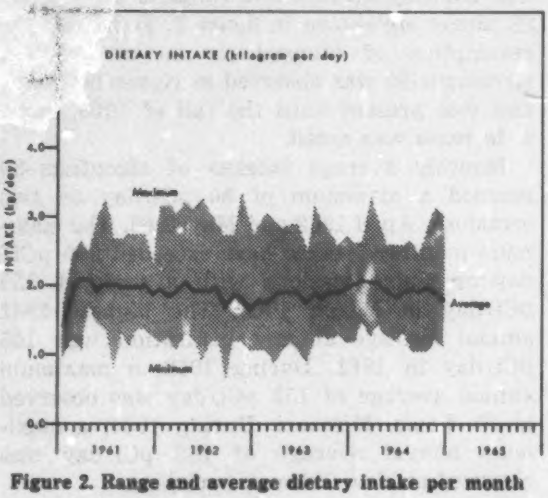


Figure 2. Range and average dietary intake per month

The monthly network average and range of dietary intake (figure 2) show a uniform dietary intake with no apparent seasonal variations. Maximum and minimum intakes are fairly constant. The maximum institutional value observed between 1961 and 1964 was 3.4 kg/day in November 1962. The minimum value was 0.6 kg/day in September 1962.

Calcium and potassium

As with dietary intake, a frequency distribution of calcium intake was developed (table 3). Over the 4-year period the average calcium intake was 1.13 g/day (figure 1). This distribution is observed to approach that of a normal distribution with a standard deviation of 0.33

g/day. The monthly network average and range of calcium intake are shown is figure 3. Although the monthly average exhibits no seasonal variation, an apparent fall peak is observed in the maximum intake. A maximum calcium intake of 3.6 g/day was observed in October 1961, with occasional minima of 0.2 g/day.

Table 3. Frequency distribution of annual average calcium intakes, 1961–1964

Range (g/day)	Number of institutions				Total	
	1961	1962	1963	1964	Number	Percent
<0.75	3	2	2		7	9
0.75–0.99	4	8	6	8	26	34
1.00–1.24	4	3	4	6	17	22
1.25–1.49	2	5	8	3	18	23
1.50–1.74	1	1	1	4	7	9
1.75–1.99		1			1	1
>2.00		1			1	1
Total	14	21	21	21	77	99
Average	1.1	1.2	1.1	1.2	—	—

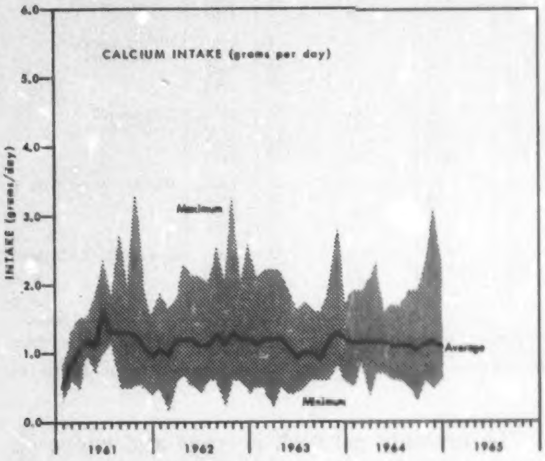


Figure 3. Range and average calcium intake per month

Annual average potassium intakes are given in table 4 as a frequency distribution. Figure 1 shows an average potassium intake of 2.7 g/day over the 4-year period of concern. Unlike dietary intake and calcium intake, the potassium distribution is skewed from that of a normal distribution toward higher intake values. Network monthly average and range of potassium intake are presented in figure 4. The average remains fairly uniform with no apparent seasonal variation. The minimum rarely falls below 1 g/day. The maximum exhibits an apparent spring rise, rarely exceeding 6 g/day.

Table 4. Frequency distribution of annual average potassium intakes, 1961–1964

Range (g/day)	Number of institutions				Total	
	1961	1962	1963	1964	Number	Percent
1.50–1.99	1	3	2	1	7	9
2.00–2.49	4	7	3	10	24	31
2.50–2.99	4	2	10	6	22	29
3.00–3.49	5	4	3	3	15	19
3.50–3.99		3	2	1	6	8
4.00–4.49			1		1	1.3
4.50–4.99		1			1	1.3
5.00–5.49		1			1	1.3
Total	14	21	21	21	77	99
Average	2.7	3.0	2.9	2.7	—	—

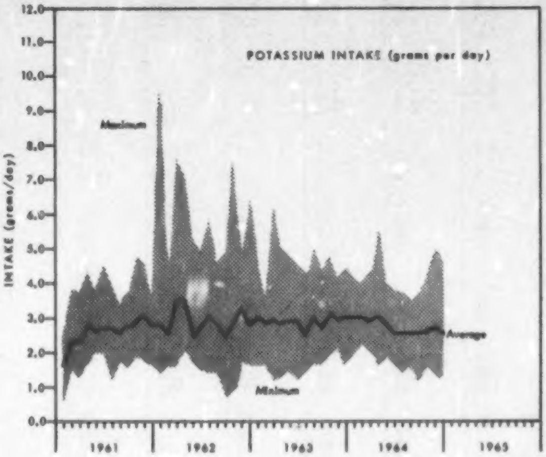


Figure 4. Range and average potassium intake per month

Strontium–89

Strontium–89 analysis was introduced in September 1961, at which time concentrations were below the detectable limit (10 pCi/kg). The monthly average and range of strontium–89 intake are shown in figure 5. Following the resumption of atmospheric nuclear testing, strontium–89 was observed in November 1961, and was present until the fall of 1963, when a decrease was noted.

Monthly average intakes of strontium–89 reached a maximum of 80 pCi/day on two occasions, April 1962 and May 1963. The maximum monthly intakes have exceeded 250 pCi/day on four occasions with a peak of 350 pCi/day in March 1963. The highest 1961 annual average at any institution was 105 pCi/day in 1961. During 1962, a maximum annual average of 152 pCi/day was observed at St. Louis, Missouri. During 1963, a maximum annual average of 182 pCi/day was observed at New Orleans, Louisiana.

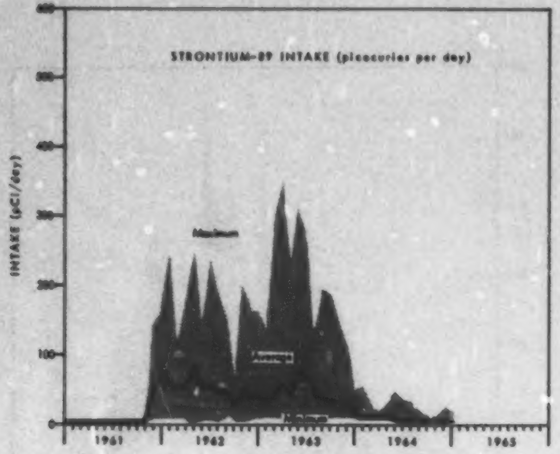


Figure 5. Range and average strontium-89 intake per month

Strontium-90

During the first 8 months of 1961 the average strontium-90 intake was 8 pCi/day (figure 6). Thereafter, a steady increase was observed until April 1964 at a rate of approximately 10 pCi/day·year. At that time a decreasing trend ensued. Similar trends were observed in the FDA Teenage Diet Survey (*4*) and the HASL Tri-City Diet Study (*5*). The highest monthly strontium-90 intake observed was 100 pCi/day in July 1963. This is within Range II (20 to 200 pCi/day) as defined by the Federal Radiation Council (*2*).

Annual average ranges were in 1961, 5 to 16 pCi/day; 1962, 4 to 29 pCi/day; 1963, 9 to 39 pCi/day; and 1964, 17 to 67 pCi/day. The 1963 maximum was in Chicago, Illinois; the 1964 maximum was in New Orleans, Louisiana.

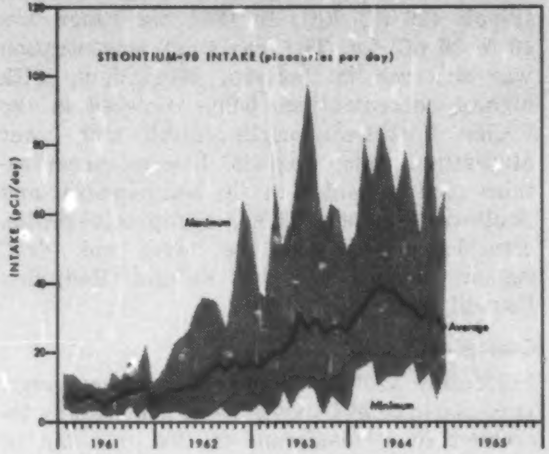
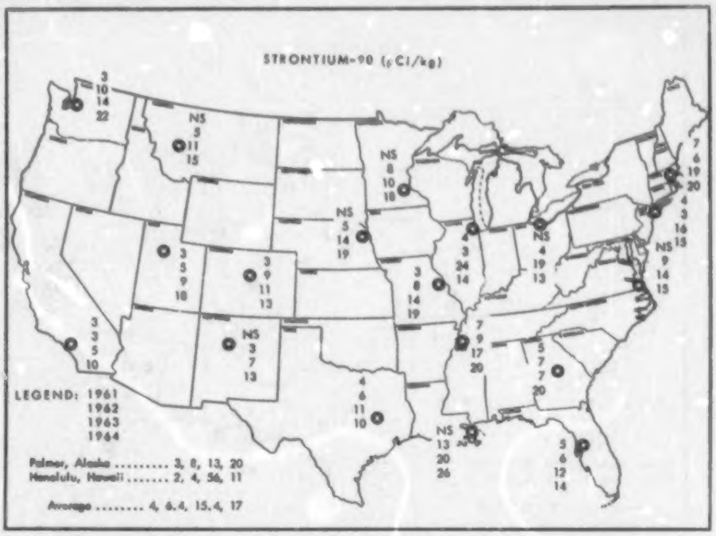


Figure 6. Range and average strontium-90 intake per month

Discussion of the results on a regional basis is more meaningful on a pCi/kg basis than a pCi/day basis, since differences in daily intakes of radionuclides may be mainly due to differences in the amounts of food consumed (*5*). The strontium-90 results on a pCi/kg basis are presented in figure 7. The observed concentra-


STRONTIUM-90 (pCi/kg)
3
10
14
22
NS
5
11
15
3
5
9
10
3
9
11
13
3
3
5
10
NS
3
7
13
NS
5
14
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NS
8
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7
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5
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12
14
7
6
19
20
4
3
16
15
NS
9
14
15
LEGEND: 1961
1962
1963
1964
Palmer, Alaska 3, 8, 13, 20
Honolulu, Hawaii 2, 4, 56, 11
Average 4, 6.4, 15.4, 17

Figure 7. Annual average strontium-90 concentration in total diet, 1961–1964

tion ranges were: 1961, 3 to 7 pCi/kg; and 1962, 3 to 13 pCi/kg. In 1963 the Southwest and Atlanta, Georgia, reported an average below 10 pCi/kg; all other station averages were from 10 to 20 pCi/kg except Chicago, Illinois (29 pCi/kg). In 1964, the range was 10 to 26 pCi/kg. The maximum concentration was observed in Jackson, Mississippi, with highest concentrations being centered in the Pacific Northwest, north-central, and lower Mississippi valley regions. Lowest concentrations tend to center in the south-central and Southwest regions. This geographic variation coincides closely with the "wet" and "dry" regions defined by the Federal Radiation Council (*6*).

Cesium–137

Monthly average cesium–137 intakes, averaged about 20 pCi/day in 1961, and steadily increased to a maximum of 200 pCi/day in March 1964 (figure 8). Network annual averages increased from 29 pCi/day in 1961 to 154 pCi/day in 1964. The maximum intake reached 565 pCi/day in December 1963. This is well below 4400 pCi/day derived from International Committee on Radiological Protection recommendations as applied to the population at large (*7*).

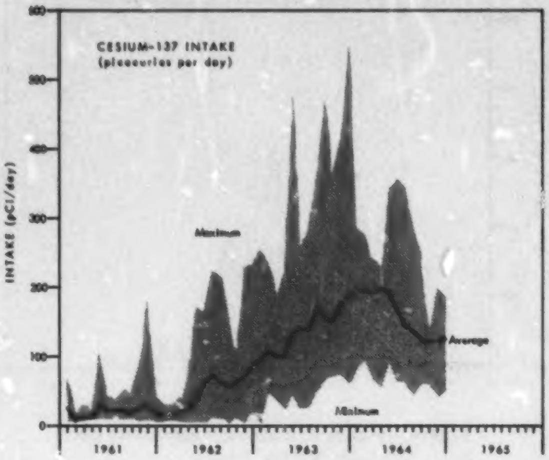

Figure 8. Range and average cesium–137 intake per month

To evaluate regional differences, results are presented graphically in figure 9. In 1961, four institutions reported average cesium–137 concentrations greater than 5 pCi/kg, the maximum being 7 pCi/kg. In 1962, the maximum concentrations were 51 pCi/kg. Proceeding from Southwest to Northeast stratified belts can be inferred: Southwest concentrations were below 20 pCi/kg; adjacent areas showed an increasing trend with higher concentrations occurring in the Great Lakes area, followed by a maximum concentration of 51 pCi/kg, in the Northeast.

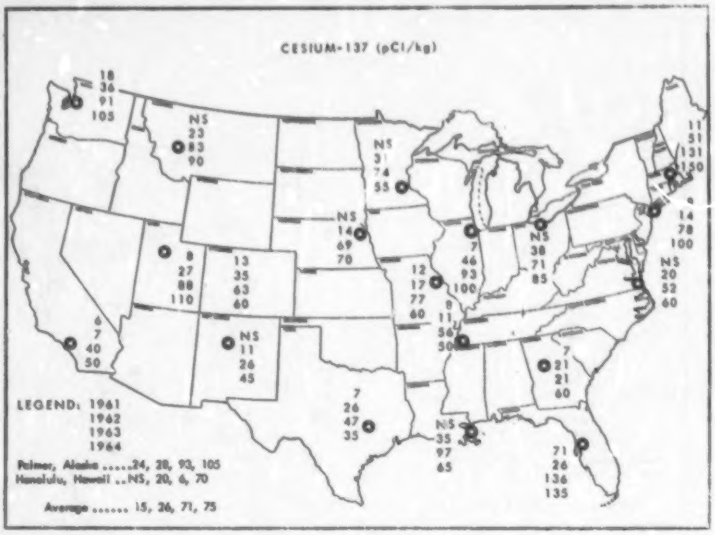
CESIUM-137 (pCi/kg)
18
36
91
105
NS
23
83
90
NS
31
74
55
11
51
131
150
NS
14
69
70
8
27
88
110
13
35
63
60
7
46
93
100
NS
38
71
85
9
14
78
100
12
17
77
60
NS
20
52
60
6
7
40
50
NS
11
26
45
8
11
56
50
7
21
21
60
7
26
47
35
NS
35
97
65
71
26
136
135
LEGEND: 1961
1962
1963
1964
Palmer, Alaska 24, 28, 93, 105
Honolulu, Hawaii ..NS, 20, 6, 70
Average 15, 26, 71, 75

Figure 9. Annual average cesium–137 concentration in total diet, 1961–1964

In 1963, similar trends were observed. The Southwest cesium–137 concentrations were below 40 pCi/kg. Northern U.S. concentrations were greater than 80 pCi/kg, ranging to 131 pCi/kg. Concentrations above 80 pCi/kg were also reported at New Orleans, Louisiana (97 pCi/kg), Tampa, Florida (136 pCi/kg), and Palmer, Alaska (93 pCi/kg).

In 1964, the same general trend from Southwest to Northeast was observed in Boston, Massachusetts, with values in excess of 100 pCi/kg in Seattle, Washington (105 pCi/kg), Salt Lake City, Utah (110 pCi/kg), and Tampa, Florida (135 pCi/kg).

An increase in cesium–137 intake has been seen from 1961 through early 1964. Current results indicate that the peak has occurred and a general decreasing trend can be expected to ensue. Comparable trends have been observed in the FDA Teenage Diet Survey (4).

Iodine–131

Iodine–131 concentrations for 1961 reflect a 4-month average since iodine–131 was not observed prior to September 1961. The maximum annual average intake of iodine–131 observed in 1961 was 85 pCi/day at Boston, Massachusetts. In 1962, the maximum was 55 pCi/day at Albuquerque, New Mexico. From September 1961 through December 1962 (16 months) the maximum daily intake of iodine–131 exceeded 100 pCi, the top of Range II as recommended by the Federal Radiation Council (2). However, monthly and annual average intakes were significantly lower. In 1963, the maximum individual monthly intake was 70 pCi/day, while the maximum annual average intake was 29 pCi/day. Network average iodine–131 intakes are observed to have decreased steadily since the initial rise in the fall of 1961, and by 1964 to below detectable levels.

Barium–140

The maximum annual average barium–140 intake was 73 pCi/day in 1962 at Helena, Montana. Since the time of the rise in barium–140 intake during late 1961 and early 1962, a decreasing trend has been observed until 1964 when barium–140 intakes had decreased to below detectable levels. Using International Committee on Radiation Protection (ICRP) maximum permissible concentrations in water for the population at large, the corresponding intake of barium–140 was 22,000 pCi/day (7). Observed barium–140 intakes were well below this value.

Summary

Results of the 21 sampling stations in the Institutional Total Diet Sampling Network since 1961 have been presented through 1964.

Particular note is made of average and range of dietary, calcium, and potassium intakes with respect to time. Where seasonal variations appear to occur in maximum intakes of calcium and potassium, no seasonal variation is observed in the network average. Dietary and calcium intakes over the 4-year period approach a normal distribution, while potassum intake is skewed toward higher intake values.

Atmospheric nuclear testing during late 1961 and 1962 resulted in a general increasing trend for radionuclide levels until 1964. Maximum intake of shorter-lived nuclides such as strontium–89, iodine–131, and barium–140 occurred during 1962 or 1963 and intakes were below detectable levels by 1964. The apparent decreases in strontium–90 and cesium–137 intakes which ensued in the fall of 1964 can be expected to continue with the cessation of atmospheric nuclear testing.

Extrapolation of the observed intakes of children in boarding schools and institutions to those of children in the general population will be investigated at such time as data regarding individual food consumption (based on probability sampling) become available.

Acknowledgements

The authors gratefully acknowledge the continuing efforts of the Technical Operations Branch, Division of Radiological Health and the Division of Environmental Engineering and Food Protection, under whose direction the sampling and analyses were carried out. The laboratory analyses were performed under the direction of Edmond J. Baratta of the Northeastern Radiological Health Laboratory, Charles Porter of the Southeastern Radiological Health Laboratory, and Ewald Pyzel of the Southwestern Radiological Health Laboratory, DRH.

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ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS,[1] NOVEMBER–DECEMBER 1964

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist, due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other source. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureaus of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized, dried, and ashed prior to stable calcium, potassium, strontium, and sodium determination being made.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium-89 and strontium-90; analysis of radium-226; and gamma spectroscopy of 1 gallon of wet sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 for November through December 1964 (*2*).

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[1] This work was summarized under the supervision of Amasa C. Cornish, Senior Health Physicist, Jack L. Brown, Associate Health Physicist, and George Barr, Radiological Health Specialist, Bureau of Radiological Health, California State Department of Public Health.

Table 1. Estimated daily intake of radionuclides in California diets,[a] November–December 1964

City	Kg/capita per day[b]	pCi/capita • day							Grams/capita • day			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce, ^{144}Ce	K[c]	Na	Ca	Stable Sr[d]
Bakersfield	2.2	0	13	1.1	53	[e] 13	0	0	2.8	3.4	1.1	0.002
Berkeley	2.7	0	10	1.2	60	20	0	0	1.8	2.5	0.7	0.001
Bishop	1.6	0	12	0.4	47	0	0	0	2.2	2.6	0.5	0.001
Brawley	NS											
Crescent City	2.2	0	36	0.8	120	17	0	0	2.8	4.7	0.9	0.002
Eureka	2.2	0	23	0.6	55	10	0	0	3.0	2.7	1.3	0.001
Fresno	2.2	0	11	3.5	83	39	0	0	2.2	3.4	1.0	0.002
Los Angeles	2.6	0	10	1.2	73	16	0	0	2.9	3.9	0.7	0.002
Needles	1.7	0	12	1.1	43	[e] 3	0	0	2.5	3.5	0.8	0.002
Quincy	1.8	0	10	1.2	93	15	0	0	2.5	3.4	0.6	0.002
Redding	2.2	0	16	1.1	57	[e] 4	0	0	2.8	5.0	0.8	0.002
Sacramento	2.1	0	12	0.7	71	17	0	0	2.5	4.4	0.7	0.001
Salinas	NS											
San Bernardino	2.2	0	14	0.9	56	18	0	0	3.4	4.3	1.2	0.001
San Diego	2.1	0	12	0.2	38	5	0	0	3.3	3.6	0.9	0.001
San Luis Obispo	1.5	0	18	1.0	68	28	0	0	2.1	3.8	0.8	0.002
Santa Barbara	NS											
Santa Rosa	2.2	0	18	0.2	98	[e] 3	0	0	3.0	3.5	1.4	0.001
Susanville	NS											
Ukiah	2.3	0	28	2.1	94	38	0	0	3.0	3.2	1.8	0.002

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive K-40.
[d] Stable strontium consists of strontium-88 (82.7 percent), strontium-87 (7.0 percent), strontium-86 (9.8 percent), strontium-84 (0.5 percent).
[e] Count rate was less than or equal to twice the 95 percent error; the value reported is the best estimate.
NS, sample lost in laboratory procedures.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

Averages for the year have been calculated for all the hospitals. The yearly averages for the selected nuclides, strontium–90, cesium–137, and radium–226 are shown in table 2.

Table 2. Annual average dietary intakes in California, 1964

City	Average intake, pCi/capita • day		
	Strontium-90	Cesium-137	Radium-226
Bakersfield	15	73	1.2
Berkeley	19	64	0.9
Bishop	13	49	0.9
Brawley	9	47	1.3
Crescent City	48	120	1.7
Eureka	22	70	1.3
Fresno	28	62	1.7
Los Angeles	13	76	1.1
Needles	16	52	1.2
Quincy	13	75	1.0
Redding	19	58	1.3
Sacramento	18	74	1.6
Salinas	16	78	0.9
San Bernardino	15	51	1.0
San Diego	14	52	0.9
San Luis Obispo	14	44	0.9
Santa Barbara	15	51	1.0
Santa Rosa	21	72	1.0
Susanville	17	89	0.6
Ukiah	21	72	1.1

The 1964 annual average strontium–90 intake in the California diet varied from 9 to 48 picocuries per capita per day with a mean of 18 picocuries per capita per day The general trend was from high in the northern part to low in the southern part of the State.

Cesium–137 intakes varied from 47 to 120 picocuries per capita per day. As with strontium–90, highest values occurred in the north and lowest values in the south.

Radium–226 intakes varied from 0.6 to 1.7 picocuries per capita per day. The highest values were in the northern coastal and central regions of the State. Higher values were observed to form a broad band running from northwest to southeast. Lowest values were observed near the eastern border of the State north of and including Inyo County, and in the coastal region south of Humbolt County.

A comparison of strontium–90 intakes with the Tri-City Diet Study (table 3) indicates that

Table 3. Strontium-90 in California and Tri-City Diet studies, 1964

Study and location	Strontium-90 (pCi/capita • day)
California Diet study:	
San Francisco	19
State average	18
State maximum	48
State minimum	9
Tri-City Diet study:	
San Francisco	14

San Francisco daily intakes for 1964 were 19 picocuries per capita per day for the California Diet Study, and 14 picocuries per capita per day for the Tri-City Diet Study (*3*). These values are observed to be in close agreement.

The magnitude of the observed intakes of strontium-90, cesium-137 and radium-226 in California diets were so low that no public health actions were indicated during 1964.

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SELECTED RESULTS FROM TOTAL DIET STUDIES,[1] FEBRUARY 1963-JUNE 1964

Since November 1959, the Consumers Union (CU) has engaged in studies of the radionuclide content of samples of teenagers' total diet collected during various periods of the year from groups in selected U.S. cities (*1-7*). It is believed that the selection of the teenager group for study will produce estimates of dietary radionuclide intake which are not likely to be exceeded by the general population. A basis for this is found in the National Research Council's recommended dietary allowances (*8*), which establish the relatively high nutritional needs of teenagers as compared with other age groups.

Originally, diet samples from 25 U.S. cities were analyzed; with the January 1962 sampling, the number of cities included was increased to 30. This report deals with analyses of diets from 23 cities, five of which have been sampled since the beginning of the program, and ten from the period May 1961 through June 1964. Comparisons of 1964 results to those of the Public Health Service Institutional Total Diet Sampling Network were published earlier (*9*).

Sampling procedures

Each diet sample from a city consisted of the total diet (food, milk, and drinking water) of teenagers for a full week (21 meals plus snacks). To help assure that the various diet samples were representative of the region in which the selected city was situated, home economists in universities were asked to prepare, based on local surveys, diets comparable to the average male teenage diet within their area. The home economist, where feasible, purchased fresh produce in local markets; frozen and canned items were substituted only when necessary.

Typical items in the menus were: hot and cold cereal, eggs, bread, milk, and other dairy products, spaghetti, beef, lamb, pork, chicken, fish, salads, vegetables, soups, fruits, fruit juices, and drinking water. Also included were snacks containing soft drinks, candy, cookies, sandwiches, cake, and ice cream. Meals were prepared as though for actual consumption with inedible parts discarded. After preparation, samples were shipped to the participating laboratories[2] for analysis. Split samples were used for cross-checking the laboratories' results. For the 10 cities continuously sampled, separate milk samples were analyzed to determine the milk contribution to the total dietary intake.

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[1] Based on data from studies performed by Mr. Irving Michelson, formerly Director of Public Service Projects, Consumers Union, in fulfillment of Public Health Service contracts SAph 76694 and PH 86-64-71 and HASL-AEC Contract No. AT (30-1)-3187.

[2] Analyses were performed by PHS Northeastern, Southeastern and Southwestern Radiological Health Laboratories and by Isotopes, Inc., Westwood, New Jersey.

Analytical program and methods

The program included analysis of each sample for stable calcium and potassium, strontium-89, strontium-90, and cesium-137. The calcium analysis has been derived from a procedure described by Yalman *et al.* (*9*). Strontium-90 was determined by beta counting its daughter, yttrium-90, which had been chemically separated from the sample. Cesium-137 determinations were made by either gamma counting directly or beta counting after chemical separation.

Sampling results

Table 1 presents the average daily dietary intake for 1963 and the first half of 1964. The total weight of food consumed ranged between 1.84 and 5.44 kg/day with most intakes falling between 3 and 4 kg/day. The daily calcium intake (table 2) ranged between 0.9 and 3.2 g/day, with approximately 80 percent of the intakes falling between 1.5 and 2.5 g/day. The daily potassium intake (table 3) ranged between 3.20 and 7.66 g/day during the period February through June 1964.

Strontium-89 intake averages (table 4) show that New Orleans, Louisiana, has consistently reported higher levels than the other cities. The maximum reported intake value was 320 pCi/day. During 1963, strontium-89 intakes were seen to steadily decrease. Similar results were observed in the Institutional Total Diet Sampling Network (*10*).

Table 1. Average daily dietary intake (kg/day) 1963-1964

Sampling locations		1963								1964			
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Feb	Apr	May	Jun
Ala:	Tuscaloosa	3.89		3.16		4.14			4.11				
Ariz:	Grand Canyon			4.44		4.27			2.86				
Ark:	Little Rock	2.47	3.56	2.60	2.46	2.41	3.24	3.50	2.89				
Calif:	Los Angeles	4.09	4.00	3.47	4.73	3.83	3.76	4.09	2.76	4.76	4.39	4.01	3.89
	San Francisco	4.60	4.14	3.24	4.14	4.27	3.63	3.24	3.01				
Idaho:	Boise	2.40				4.19			3.01				
Ill:	Chicago	3.90	3.63	3.69	4.07	3.71	3.57	3.44	3.87	3.63	4.33	3.63	3.66
La:	New Orleans	3.17	2.99	3.31	3.43	3.39	3.63	2.99	3.09	2.91	3.2[illegible]	3.89	3.09
Maine:	Portland	1.84		3.24		3.66			3.40				
Minn:	Duluth	3.84	3.60	3.73	3.50	4.04	3.37	3.06	4.40				
Mo:	St. Louis	4.73		4.80		3.80			3.49	3.91	4.11	3.39	3.64
Nev:	Reno	4.09		3.60		3.50			3.01				
N. Y:	Buffalo	4.06		3.63		3.44			3.54	3.79	3.97	2.24	3.31
	New York	2.97	3.60	3.67	3.56	3.53	3.63	3.57	3.41	3.43	4.70	3.57	3.59
N. Dak:	Bismark	4.99		4.21		3.24			2.86	3.27	3.64	3.17	2.77
Okla:	Oklahoma City	4.29		3.49		2.73			3.27				
Ore:	Portland	3.11	4.21	3.63	4.53	3.89	3.54	3.44	2.89	4.37	4.37	3.23	4.20
S. C:	Columbia	2.81		3.11		3.17			2.86				
S. Dak:	Sioux Falls	3.64	4.01	3.47	3.37	3.44	4.03	2.86	3.40				
Tenn:	Knoxville	4.24	3.40	3.61	3.89	3.53	3.44	3.63	3.30	4.24	4.13	3.91	4.37
Utah:	Salt Lake City									3.70	4.27	3.43	3.54
W. Va:	Charleston	4.61		4.34		3.91			3.29				
Wyo:	Casper	5.44		3.34		3.43			2.30				
Average		3.77	3.74	3.61	3.77	3.61	3.58	3.38	3.23	3.80	4.11	3.45	3.61

Blanks indicate no sample collected.

Table 2. Average daily calcium intake (g/day), 1963-1964

Sampling locations		1963								1964			
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Feb	Apr	May	Jun
Ala:	Tuscaloosa	2.3		1.8		2.1			1.7				
Ariz:	Grand Canyon			2.0		1.7			1.3				
Ark:	Little Rock	1.7	2.1	1.6	1.4	1.5	2.0	2.0	1.8				
Calif:	Los Angeles	1.6	2.0	1.8	2.0	1.9	1.7	1.7	1.4	2.5	2.1	2.3	1.9
	San Francisco	2.4	2.6	1.6	2.3	2.0	1.9	1.7	1.4				
Idaho:	Boise	1.4				1.9			1.5				
Ill:	Chicago	2.4	1.9	2.2	2.1	2.0	2.1	1.8	2.0	2.4	2.4	1.9	2.2
La:	New Orleans	1.8	1.9	2.0	1.9	1.7	2.0	1.4	1.9	1.9	2.0	2.1	1.9
Maine	Portland	0.9		1.7		1.9			1.9				
Minn:	Duluth	2.0	1.8	2.2	1.7	2.1	1.5	1.5	2.2				
Mo:	St. Louis	2.6		2.6		2.3			2.0	2.3	2.3	2.0	2.3
Nev:	Reno	2.0		2.0		1.6			1.5				
N. Y:	Buffalo	2.3		2.1		1.9			2.1	2.1	2.0	1.8	1.9
	New York	1.8	1.8	2.1	1.7	2.0	2.1	1.8	2.6	2.2	2.6	1.8	2.0
N. Dak:	Bismark	2.2		2.3		2.4			1.5	2.2	2.1	2.0	1.6
Okla:	Oklahoma City	2.6		1.9		1.1			1.8				
Ore:	Portland	1.5	2.5	2.0	2.1	2.0	1.8	1.7	1.6	3.0	2.3	2.6	2.3
S. C:	Columbia	2.0		2.1		1.9			1.9				
S. Dak:	Sioux Falls	1.9	2.1	1.8	1.6	1.8	2.3	1.4	1.9				
Tenn:	Knoxville	2.1	1.9	2.1	2.1	2.1	2.1	2.4	2.3	2.8	2.4	2.3	3.2
Utah:	Salt Lake City									2.4	2.4	2.0	2.2
W. Va:	Charleston	2.3		2.3		2.3			1.7				
Wyo:	Casper	2.9		1.8		1.5			1.1				
Average		2.0	2.1	2.0	1.9	1.9	2.0	1.7	1.8	2.4	2.3	2.1	2.2

Table 3. Average daily potassium intake (g/day), 1964

Sampling locations		1964			
		Feb	Apr	May	Jun
Ala:	Tuscaloosa				
Ariz:	Grand Canyon				
Ark:	Little Rock				
Calif:	Los Angeles	7.66	6.80	6.02	5.41
	San Francisco				
Idaho:	Boise				
Ill:	Chicago	4.33	5.80	4.97	4.80
La:	New Orleans	3.20	3.48	4.90	3.55
Maine:	Portland				
Minn:	Duluth				
Mo:	St. Louis	5.38	5.35	4.75	4.00
Nev:	Reno				
N.Y:	Buffalo	5.08	5.60	4.18	3.54
	New York	5.25	7.05	5.07	4.52
N. Dak:	Bismark	4.38	5.27	4.03	3.96
Okla:	Oklahoma City				
Ore:	Portland	7.14	6.47	6.18	5.04
S. C:	Columbia				
S. Dak:	Sioux Falls				
Tenn:	Knoxville	5.34	5.74	5.90	6.03
Utah:	Salt Lake City	6.00	6.56	4.15	4.81
W. Va:	Charleston				
Wyo:	Casper				
Average		5.39	5.81	5.09	4.57

Steadily increasing strontium-90 intakes since the resumption of atmospheric nuclear testing in 1961 were observed, with a peak in 1964 (table 5). The maximum intake observed for any month was 140 pCi/day in May 1963 (*9*).

Cesium-137 intakes (table 6) were seen to parallel strontium-90 intakes, reaching a peak in 1964. The maximum daily intake of 720 pCi/day was observed in February 1964.

The relationship between calcium intakes in milk and diet are given in table 7. For comparison purposes it was assumed that five cups (1.183 liters) of milk were consumed per day.

Table 4. Average daily strontium-89 intake (pCi/day), 1963

Sampling locations		1963							
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Ala:	Tuscaloosa	290		190		205			80
Ariz:	Grand Canyon			45		45			<5
Ark:	Little Rock	110	160	220	160	195	65	105	70
Calif:	Los Angeles	40	40	35	45	30	<5	40	<40
	San Francisco	160	185	260	185	105	35	15	15
Idaho:	Boise	145				125			30
Ill:	Chicago	40	<20	20	20	110	35	70	20
La:	New Orleans	320	315	280	105	135	55	75	95
Maine:	Portland	20		<5		75			70
Minn:	Duluth	40	<20	<20	<20	180	15	215	45
Mo:	St. Louis	95		60		190			<15
Nev:	Reno	20		20		120			45
N. Y:	Buffalo	80		20		105			35
	New York	15	20	35	20	125	35	125	100
N. Dak:	Bismark	100		30		245			120
Okla:	Oklahoma City	105		105		95			65
Ore:	Portland	80	85	145	25	235	140	70	45
S. C:	Columbia	140		220		160			85
S. Dak:	Sioux Falls	35	<20	35	50	140	60	45	35
Tenn:	Knoxville	65	70	200	95	210	70	35	85
Utah:	Salt Lake City								
W. Va:	Charleston	45		150		255			100
Wyo:	Casper	55		15		70			25
Average		95	90	99	102	143	51	80	56

Table 5. Average daily strontium-90 intake (pCi/day), 1963-1964

Sampling locations		1963								1964			
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Feb	Apr	May	Jun
Ala:	Tuscaloosa	39		41		66			45				
Ariz:	Grand Canyon			40		73			31				
Ark:	Little Rock	32	53	47	57	60	94	80	66				
Calif:	Los Angeles	11	14	19	23	23	22	18	12	28	26	31	19
	San Francisco	24	32	36	46	47	27	27	18				
Idaho:	Boise	19				71			36				
Ill:	Chicago	26	24	25	34	45	43	41	43	43	47	41	44
La:	New Orleans	51	69	76	51	47	83	69	65	67	82	92	85
Maine:	Portland	15		31		48			65				
Minn:	Duluth	38	44	45	38	77	57	52	62				
Mo:	St. Louis	39		40		72			66	52	42	56	67
Nev:	Reno	24		18		49			39				
N. Y:	Buffalo	26		25		52			57	50	59	46	59
	New York	17	26	27	30	49	91	71	136	55	61	56	72
N. Dak:	Bismark	31		63		110			63	84	92	101	83
Okla:	Oklahoma City	43		33		27			49				
Ore:	Portland	34	42	54	140	86	85	52	43	66	80	83	71
S. C:	Columbia	34		50		51			69				
S. Dak:	Sioux Falls	29	35	35	29	48	77	88	41				
Tenn:	Knoxville	38	28	43	66	85	100	87	92	66	66	91	97
Utah:	Salt Lake City									52	55	48	47
W. Va:	Charleston	37		38		71			56				
Wyo:	Casper	29		22		45			21				
Average		31	37	38	51	62	68	59	53	56	61	65	56

Table 6. Average daily cesium-137 intake (pCi/day), 1963–1964

Sampling locations		1963								1964			
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Feb	Apr	May	Jun
Ala:	Tuscaloosa	115		190		250			185				
Ariz:	Grand Canyon			65		45			100				
Ark:	Little Rock	85	180	180	195	240	325	370	215				
Calif:	Los Angeles	40	100	70	95	135	130	185	125	260	220	260	160
	San Francisco	45	125	160	205	280	255	310	120				
Idaho:	Boise	70				250			180				
Ill:	Chicago	115	145	150	185	280	270	290	270	280	370	320	260
La:	New Orleans	160	210	215	275	170	255		200	380	410	370	260
Maine:	Portland	65		195		330			410				
Minn:	Duluth	220	220	280	175	425	305	290	395				
Mo:	St. Louis	165		145		305			140	290	350	270	280
Nev:	Reno	80		55		210			255				
N. Y:	Buffalo	205		180		240			300	360	390	310	330
	New York	135	110	185	160	280	410	430	375	280	460	330	420
N. Dak:	Bismark	175		125		80			230	405	440	350	320
Okla:	Oklahoma City	130		140		165			115				
Ore:	Portland	125	190	220	520	430	400	325	245	720	700	700	550
S. C.:	Columbia	125		185		220			185				
S. Dak:	Sioux Falls	200	180	190	120	275	320		220				
Tenn:	Knoxville	105	120	160	155	280	360	455	235	360	410	410	390
Utah:	Salt Lake City									460	600	420	420
W. Va:	Charleston	140		150		275			195				
Wyo:	Casper	110		100		190			140				
Average		125	158	159	209	243	324	266	220	370	434	374	339

Table 7. Ratio of calcium intake from milk relative to calcium intake from diet

Station		1964			
		Feb	Apr	May	Jun
Calif:	Los Angeles	0.56	0.67	0.57	0.68
Ill:	Chicago	0.58	0.56	0.74	0.59
La:	New Orleans	0.79	0.75	0.71	0.79
Mo:	St. Louis	0.61	0.61	0.70	0.61
N. Y:	Buffalo	0.67	0.70	0.78	0.68
	New York	0.64	0.54	0.89	0.65
S. Dak:	Sioux Falls	0.64	0.67	0.70	0.88
Ore:	Portland	0.53	0.65	0.58	0.61
Tenn:	Knoxville	0.57	0.58	0.61	0.41
Utah:	Salt Lake City	0.63	0.55	0.70	0.59

Table 8 shows the relationship of strontium-90 in milk to strontium-90 in the total diet. The wide range of this ratio gives some indication that only a relative idea of the strontium-90 intake from the diet can be obtained from determinations of strontium-90 in milk alone.

Table 8. Ratio of strontium-90 intake from milk relative to strontium-90 intake from diet

Station		1964			
		Feb	Apr	May	Jun
Calif:	Los Angeles	0.25	0.46	0.29	0.32
Ill:	Chicago	0.63	0.32	0.66	0.57
La:	New Orleans	1.00	0.80	0.80	0.73
Mo:	St. Louis	0.46	0.64	0.59	0.64
N. Y:	Buffalo	0.46	0.37	0.48	0.66
	New York	0.46	0.44	0.66	0.50
S. Dak:	Sioux Falls	0.74	0.57	0.79	1.00
Ore:	Portland	0.45	0.59	0.76	0.66
Tenn:	Knoxville	0.53	0.74	0.74	0.45
Utah:	Salt Lake City	0.62	0.60	0.71	0.66

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STRONTIUM-90 IN TRI-CITY DIETS FEBRUARY–APRIL 1965 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium–90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium–90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium–90 over the last four years has been approximately five percent. Therefore, this figure is used to calculate the contribution of these food categories to the total diet strontium–90 intake. These values are added to the contributions of the other 14 food categories to obtain quarterly estimates of annual strontium–90 intake at the three cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been previously summarized (*3*).

Results of the February to April 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

Table 1. Average dietary consumption, calcium, and strontium-90 intake for February to April 1965 sampling

Food category	Diet (kg/yr)	Calcium (g/yr)	Strontium-90 intake					
			New York City—2/65		Chicago—4/65		San Francisco—3/65	
			pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Bakery products	37	37.0	23.2±0.6	858	23.1±1.2	855	10.2±0.8	377
Whole grain products	11	10.0	39.5±0.7	434	46.6±1.4	513	23.2±1.2	255
Fresh vegetables	43	15.0	12.7±0.4	546	9.9±0.4	426	3.6±0.3	155
Root vegetables	17	6.1	13.0±0.3	221	9.9±0.4	168	8.7±0.4	148
Milk	221	234.4	18.3±0.4	4,044	15.6±0.5	3,447	15.5±0.5	3,426
Flour	43	8.6	28.3±0.3	1,217	23.2±0.5	998	6.1±0.3	262
Macaroni	3	0.7	14.9±0.4	45	18.0±0.6	54	8.9±0.4	27
Rice	3	1.1	4.1±0.3	12	5.3±0.3	16	3.3±0.2	10
Dried beans	3	2.9	20.2±0.8	61	34.9±1.9	105	16.7±1.4	50
Fresh fruit	68	12.6	5.3±0.2	360	4.1±0.3	279	3.2±0.3	218
Potatoes	45	5.8	12.0±0.5	540	7.9±0.8	356	3.9±0.3	176
Canned fruit	26	1.3	3.3±0.1	86	4.0±0.2	104	2.3±0.2	60
Fruit juices	19	1.7	4.8±0.2	91	6.8±0.3	129	5.2±0.3	99
Canned vegetables	20	4.2	13.1±0.4	262	11.8±0.5	236	2.6±0.3	52
Meat, fish, poultry, shellfish and eggs	99	42		[a] 462		[a] 405		[a] 280
Annual intake		383		9,239		8,092		5,595
pCi ^{90}Sr/g Ca				24.1		21.1		14.6

[a] Estimated as 5 percent of total intake.

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[1] Data from Fallout Program Quarterly Summary Report (for the period June 1 through September 1) October 1, 1965, HASL–164. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

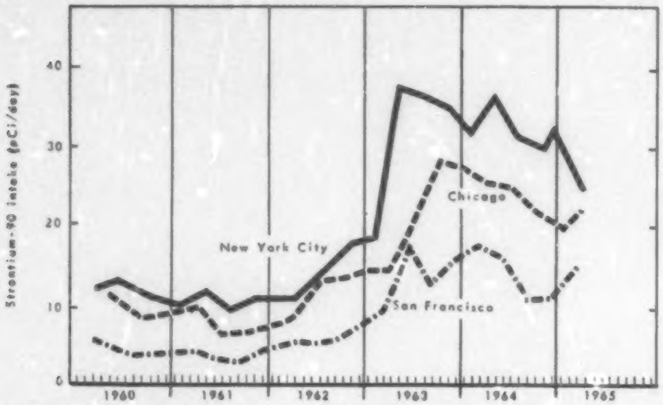

Figure 1. Daily intake of strontium-90 in New York City, Chicago, and San Francisco

Discussion

The previously noted geographic distribution pattern of strontium-90 in the diet is seen to persist as it has since the initial samplings in 1960. Levels have been highest in New York City and lowest in San Francisco. In all three cities the strontium-90 intake is observed to increase with respect to the previous sampling period 3 months earlier. This is presumed to reflect the anticipated spring rise. Due in part to its high annual consumption, milk continues to be the predominant source of strontium-90 in diet.

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Recent coverage in *Radiological Health Data:*

Period	Issue
Sixteenth Sampling (February 1964–April 1964)	*December 1964*
Seventeenth Sampling (July–September 1964)	*March 1965*
Eighteenth Sampling (August-October 1964)	*June 1965*
Nineteenth Sampling (November 1964–January 1965)	*September 1965*

Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JUNE 1965

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–8*).

Sampling procedures

The participating agencies collect 1-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term increases in radioactivity from current or recent nuclear tests or events.

Analytical methods

The analytical method for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*9*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Normally, samples are counted within 2 weeks following collection or within 1 week after compositing. The decay of activity is followed for each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Results

Table 1 presents the most recent results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative locations, the first stations listed being closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

Table 1. Radioactivity in raw surface waters, June 1965[a]

(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	15	6	21	4	1	5
Apalachicola River:						
Chattahoochee, Fla.	1	4	5	0	0	0
Arkansas River:						
Coolidge, Kans.	64	312	376	12	19	31
Ponca City, Okla.	127	24	151	28	1	29
Atchafalaya River:						
Morgan City, La.	20	13	33	7	1	8
Bear River:						
Preston, Idaho	2	16	18	0	1	1
Big Horn River:						
Hardin, Mont.	85	14	99	18	3	21
Chena River:						
Fairbanks, Alaska	9	6	15	2	1	3
Clearwater River:						
Lewiston, Idaho	2	3	5	0	0	0
Clinch River:						
Clinton, Tenn.	1	3	4	0	0	0
Kingston, Tenn.	1	20	21	0	0	0
Colorado River:						
Loma, Colo.	30	11	41	9	3	12
Page, Ariz.	1	20	21	<1	5	5
Parker Dam, Calif-Ariz.	1	23	24	0	6	6
Columbia River:						
Wenatchee, Wash.	0	8	8	0	0	0
Pasco, Wash.	15	96	111	0	<1	<1
Clatskanie, Ore.	27	48	75	<1	0	<1
Connecticut River:						
Enfield Dam, Conn.	1	6	7	0	0	0
Coosa River:						
Rome, Ga.	2	4	6	1	0	1
Cumberland River:						
Cheatham Lock, Tenn.	2	8	10	1	0	1
Delaware River:						
Philadelphia, Pa.	1	7	8	0	0	0
Escambia River:						
Century, Fla.	—	—	—	—	—	—
Great Lakes:						
Duluth, Minn.	0	3	3	0	0	0
Green River:						
Dutch John, Utah	<1	18	18	0	4	4
Hudson River:						
Poughkeepsie, N.Y.	1	11	12	0	0	0
Illinois River:						
Peoria, Ill.	6	12	18	1	1	2
Grafton, Ill.	—	—	—	—	—	—
Kansas River:						
De Soto, Kans.	111	20	131	29	1	30
Klamath River:						
Keno, Ore.	1	14	15	0	0	0
Maumee River:						
Toledo, Ohio	2	12	14	1	2	3
Merrimack River:						
Lowell, Mass.	1	6	7	0	0	0
Mississippi River:						
St. Paul, Minn.	5	30	35	0	3	3
E. St. Louis, Ill.	16	17	33	3	1	4
New Roads, La.	25	14	39	7	1	8
New Orleans, La.	20	13	33	6	1	7
Missouri River:						
Williston, N. Dak.	8	15	23	1	3	4
Bismarck, N. Dak.	7	19	26	1	4	5
St. Joseph, Mo.	106	22	128	21	4	25
North Platte River:						
Henry, Nebr.	14	30	44	2	14	16
Ohio River:						
Toronto, Ohio	1	10	11	0	0	0
Huntington, W. Va.	1	10	11	0	1	1
Cairo, Ill.	2	8	10	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	4	4	8	1	<1	1
Platte River:						
Plattsmouth, Nebr.	277	27	304	72	2	74
Potomac River:						
Washington, D.C.	0	7	7	0	1	1
Rainy River:						
Baudette, Minn.	3	16	19	0	0	0
Red River, North:						
Grand Forks, N. Dak.	19	34	53	4	2	6
Red River, South:						
Index, Ark.	2	21	23	0	0	0
Alexandria, La.	10	14	24	3	1	4
Rio Grande:						
Alamosa, Colo.	—	—	—	—	—	—
El Paso, Tex.	50	16	66	17	5	22
Laredo, Tex.	96	16	112	23	2	25
Brownsville, Tex.	—	—	—	—	—	—
Sacramento River:						
Greens Landing, Calif.	1	3	4	0	0	0
San Joaquin River:						
Vernalis, Calif.	3	5	8	1	1	2
San Juan River:						
Shiprock, N. Mex.	40	9	49	12	1	13
Savannah River:						
Port Wentworth, Ga.	3	8	11	<1	0	<1
Snake River:						
Payette, Idaho	2	6	8	1	1	2
Wawawai, Wash.	4	3	7	1	0	1
South Platte River:						
Julesburg, Colo.	15	58	73	2	38	40
Susquehanna River:						
Conowingo, Md.	0	5	5	0	0	0
Tennessee River:						
Chattanooga, Tenn.	1	8	9	0	0	0
Wabash River:						
New Harmony, Ind.	21	11	32	4	1	5
Yellowstone River:						
Sidney, Mont.	99	11	110	25	3	28
Maximum	277	312	376	72	38	74
Minimum	0	3	3	0	0	0

[a] These data are preliminary: reanalysis of some samples may be made and additional analyses not completed at the time of this report may become available. For final data, one should consult the system's annual report.

Dashes indicate no sample.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha and/or beta activity whereas fallout primarily contributes additional beta activity.

The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*10*). The Public Health Service Drinking Water Standards state that when strontium-90 and unidentified alpha emitters are a negligibly small fraction of the specific limits of 10 pCi/liter and 3 pCi/liter, respectively, a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*11*). Table 2 indicates stations at which radioactivity was relatively high. These higher values almost always reflect high suspended or dissolved solids.

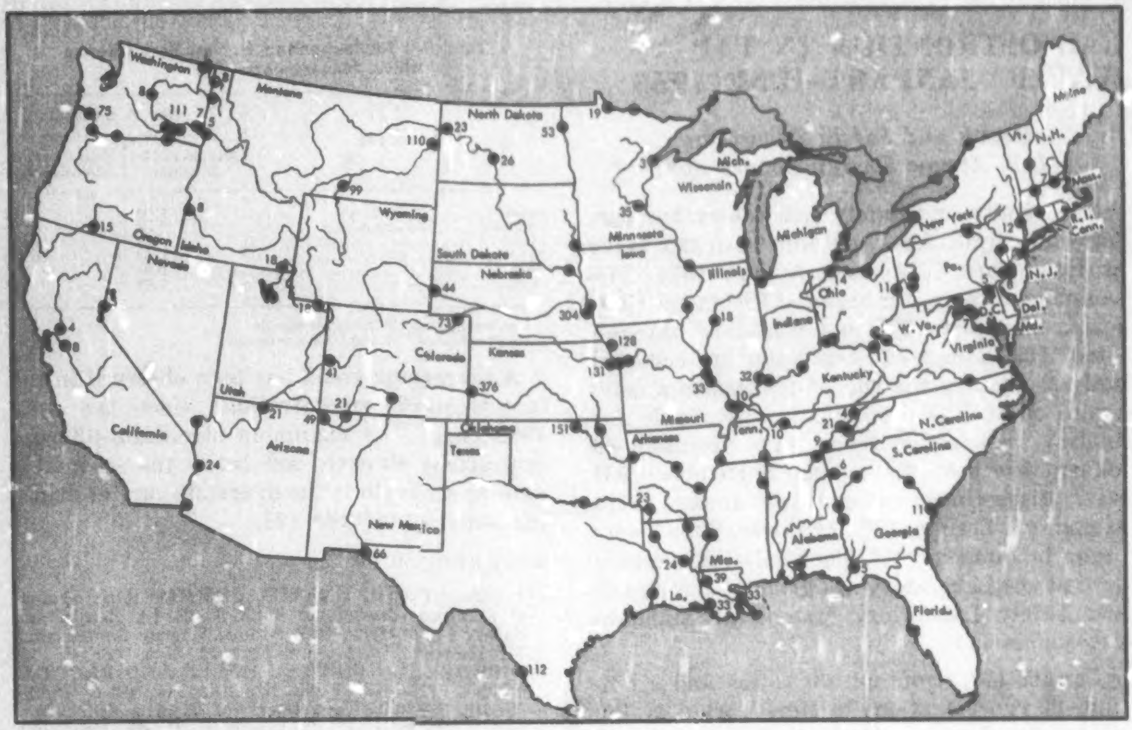
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Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, June 1965

Table 2. Summary, June 1965

Station	Sample activity	Remarks
Arkansas River:		
Coolidge, Kans......	α, Dissolved, 19 pCi/liter. β, Dissolved, 312 pCi/liter.	143 mg/liter dissolved solids. A marked reduction from May 1965.
Ponca City, Okla....	α, Suspended, 28 pCi/liter.	Sample contained 1,316 mg/liter suspended solids.
Big Horn River:		
Hardin, Mont.......	α, Suspended, 18 pCi/liter.	Sample contained 1,208 mg/liter suspended solids.
Kansas River:		
DeSoto, Kans.......	α, Suspended, 29 pCi/liter.	Sample contained 1,552 mg/liter suspended solids.
Missouri River:		
St. Joseph, Mo......	α, Suspended, 21 pCi/liter.	Sample contained 1,484 mg/liter suspended solids.
Platte River:		
Plattsmouth, Nebr..	α, Suspended, 72 pCi/liter. β, Suspended, 277 pCi/liter.	Sample contained 4,423 mg/liter suspended solids.
Rio Grande:		
El Paso, Tex........	α, Suspended, 17 pCi/liter	Sample contained 539 mg/liter suspended solids.
Laredo, Tex........	α, Suspended, 27 pCi/liter.	Sample contained 1,488 mg/liter suspended solids. Of five samples, four were in the normal low range of suspended solids and one collected 6/15/65 showed the only high level.
Yellowstone River:		
Sidney, Mont.......	α, Suspended, 25 pCi/liter.	Sample contained 1,771 mg/liter suspended solids.

REFERENCES

(1) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.50.
(2) *Ibid.*, 1959 Edition. Price $1.75.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(7) *Ibid.*, 1964 Edition (in preparation).
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(9) AMERICAN PUBLIC HEALTH ASSOCIATION, AMERICAN WATER WORKS ASSOCIATION, and WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater. 11th Edition New York (1960).
(10) STRAUB, C. P., Significance of radioactivity data. JAWWA 53:704 (June 1961).
(11) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).[1]

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[1] Single free copies of this publication may be obtained from Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

RADIOSTRONTIUM IN TAP WATER[1] JANUARY-JUNE 1965

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. The sampling of tap water began at Richmond, California in April 1958 and continued through June 1963. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Determinations of strontium-89 which have been made since September 1961 were discontinued after the January 1964 sampling. Cesium-137 determinations were begun in January 1964. The analytical methods used at the Laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Cesium-137/strontium-90 ratios and strontium-90 concentrations in New York City tap water for January through June 1965 are presented in table 1. Strontium-90 concentrations appear graphically in figure 1.

Table 1. Radiostrontium in New York City tap water, January-June 1965

Month 1965	New York City	
	Strontium-90 [a] (pCi/liter)	Cesium-137/ Strontium-90
January	1.62	0.08
February	1.58	0.10
March	1.32	0.09
April	1.64	0.13
May	1.34	[b] AIP
June	1.73	0.12

[a] Approximately 100 liters per sample
[b] AIP indicates ^{137}Cs analysis in progress.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-38-01-16, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42—Public Health, Chapter 1—Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards, 27:2154-2155, Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data:*

Period	Issue
January-April 1962	*September 1962*
March-June 1962	*January 1963*
July-December 1962	*July 1963*
January-April 1963	*January 1964*
May-October 1963	*April 1964*
November 1963-December 1964	*June 1965*

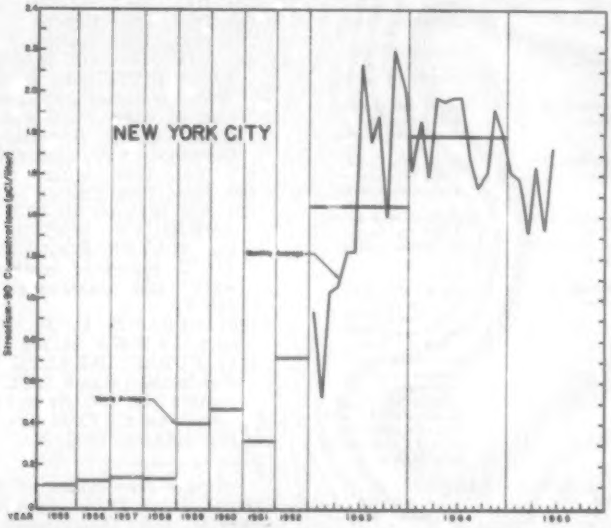

Figure 1. Strontium-90 concentrations in New York City tap water

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL-164. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151. Price $7.00.

Section IV—Other Data

THE HALF-TIME OF CESIUM-137 IN MAN[1]

T. F. McCraw[2]

As a part of participation in the Federal Radiation Council Working Group and *Ad Hoc* Panel on Strontium and Cesium Radionuclides that developed Report No. 7, the available material and data on the half-time of cesium–137 in man were reviewed. The purpose of this effort was to collect data on measured values of cesium–137 half-time that could be employed, together with other material, to support the use of an assumed value of biological half-life in whole body and bone marrow dose calculations.

This report represents (1) collected data on measured values of cesium–137 half-time in man, (2) a suggested model for expressing cesium–137 half-time as a function of age, and (3) estimates of doses and body burdens for a given intake of cesium–137 and for intake of cesium–137 in milk, using an assumed pattern of milk consumption by various ages.

One important consideration in determining whole body and bone marrow radiation dose to an exposed population from internal cesium–137 is the effective half-time of this radionuclide in man. Should there be a different biological half-time for cesium–137 in various age groups within a population and an effective half-time[3] which varies as a function of age, it will be necessary to consider this factor in determining doses to the population and in determining which age group in the population will receive the highest exposure from a contaminating event.

Available data

Table 1 lists data from the literature. The symbol T_b will be used to represent the biological half-time of cesium–137 in man. Where possible, the range of observed values for each group of individuals studied is included.

Discussion of data

Rather than present individual measurements of T_b for each subject, many investigators have reported an average value with an indication of the range of observed values. Considering the lower limits of the range of values for "adults" (unweighted for number of subjects) for all investigators where a range was given, the average value for the lower limits is about 78 days. The average value for the upper limits is about 122 days, and the overall average is about 98 days for these data.

The unweighted mean of the "Body Radioactivity Measurements and Excretion or Dietary Analysis" data from Rundo's summary is 110 days. The "Body Radioactivity Measurements" give an unweighted mean of 108 days. The "Excretion or Dietary Analysis" data give an unweighted mean of 114 days. Thus, the two techniques appear to give results which are in close agreement.

The data collected on T_b for groups of subjects are presented graphically in figure 1. Also plotted are individual values for 6- and 8-year-old girls and for two infants (Rundo), and values for three young women and two infants (Bengtsson *et al.*). In order to display the data for "adults", it has been assumed that this age group consists of those about 20 to 25 years of age and older, and the elderly are assumed to be over 60 years of age.

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[1] Adapted from HASL–164:281–300, Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151 (October 1, 1965). Price $7.00.

[2] Mr. McCraw is a Health Physicist with the Division of Operational Safety, Atomic Energy Commission, Germantown, Maryland.

[3] For cesium–137 in man, the radiological half-time is so long (about 11,000 days) and the biological half-time is so short (of the order of 100 days or less) that for purposes of this report, the effective half-time can be considered equal to the biological half-time.

Table 1. Cesium-137 half-time data from the literature

Group	Age (years)	T_b (days)	Range (days)[a]	Reference
1 girl	6	34	—	(1)
1 girl	8	39	—	(1)
children	<10	50	—	(1)
limited data	all ages	105	std. deviation 35%	(1)
small group	adults	74	—	[illegible]
9	18-22	68	—	[illegible]
30 men	16-75	64	±10	[illegible]
33 women	17-76	65.5	±10	[illegible]
17 boys	10-14	44	+10 −5	[illegible]
Eskimos	adults	100	—	[illegible]
30 males	30-40	81	48 in summer 119 in winter	[illegible]
4 children	6-15	½ the value for adults.	—	[illegible]
Marshallese people		70	—	[illegible]
10	normal subjects	^{b} 1	0.8-1.2	[illegible]
		^{c} 89	58-139	[illegible]
4	men	—	109-149	[illegible]
1	adult	53 (in 1959) 55 (in 1961)		[illegible]
1	adult	94	—	[illegible]
1	adult	138	—	[illegible]
average value		110	—	[illegible]
average value		140	—	[illegible]
2	adults	^{d} 110	—	[illegible]
3	adults	^{d} 115	110-119	[illegible]
1	adult	^{d} 74	—	[illegible]
1	adult	^{d} 144	—	[illegible]
2	adults	^{d} 60	57-63	[illegible]
4	adults	^{d} 135	110-147	[illegible]
1	adult	^{d} 150	—	[illegible]
4	adults	^{d} 122	100-148	[illegible]
5	adults	^{d} 75	54-114	[illegible]
4	adults	^{d} 100	79-123	[illegible]
10	adults	^{d} 89	58-129	[illegible]
6	adults	^{e} 145	—	[illegible]
2	adults	^{e} 125	92-157	[illegible]
1	adult	^{e} 188	—	[illegible]
91	adults	^{e} 110	—	[illegible]
2	adults	^{e} 56	53-60	[illegible]
5	adults	^{e} [illegible]	86-112	[illegible]
2	adults	^{e} 170	140-200	[illegible]
3	adults	^{e} 97	53-140	[illegible]
1	adult	^{e} 71	—	[illegible]
10	adults	^{e} 76	—	[illegible]
3	adults	99	76-126	(10)
1	adult	81	—	(11)
1	adult	95	—	(11)
1 woman-IB	22	60	±4	(12)
		65	^{f} ±5	(12)
1 woman	26	73	±10	(12)
1 woman-EB	23	32	±2	(12)
1 infant of IB	12 days	21	±5	(12)
1 infant of EB	2 days	25	±3	(12)
1 infant	early infancy	9.6	—	(13)
1 infant	early infancy	6.6	—	(13)
12	adults	91	±18	(14)
1 infant	17 days	13	—	(15)
1 infant	24 days	33	—	(15)
1 infant	36 days	21	—	(15)
1 infant	86 days	18	—	(15)
1 infant	143 days	12	—	(15)
1 child	5	29	—	(15)
1 child	5	43	—	(15)
1 child	9	40	—	(15)
1 adult	21	108	—	(15)
1 adult	23	100	—	(15)
1 adult	24	77	—	(15)
1 adult	31	78	—	(15)
1 adult	32	101	—	(15)
1 adult	33	121	—	(15)
1 adult	35	131	—	(15)
1 adult	33	94	—	(15)
1 adult	45	108	—	(15)
1 adult	46	84	—	(15)
1 adult	47	136	—	(15)
1 adult	51	73	—	(15)
1 adult	52	101	—	(15)
3	elderly women	^{g} 3.3	±2.0	(16)
		^{h} 57	±17	(16)
2	elderly men	^{g} 2.2	±1.4	(16)
		^{h} 60	±16	(16)

[a] The uncertainty in the measurement is given, when available, where data are presented for one subject.
[b] Small fraction eliminated
[c] Major fraction eliminated
[d] Body radioactivity measurement
[e] Excretion or dietary analysis
[f] Ten months later
[g] Fast component
[h] Slow component

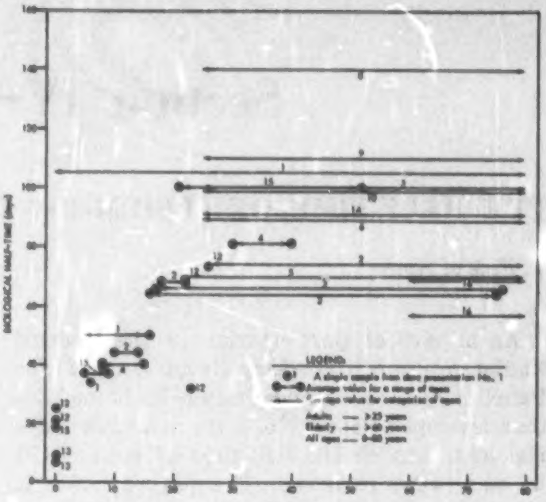

Figure 1. Biological half-time versus age

From table 1 and from figure 1, it is seen that much of the data on T_b are for "adults", and that investigators have reported half-times, for adult groups, of about one day for a small fraction of the cesium-137 intake (about 10 percent) and values between about 60 and 180 days for the major portion of the intake. While part of the difference in values from various investigators may lie in the realm of factors of instrumentation, calibration, laboratory technique, etc., the measured values generally appear to represent real differences among individuals. The range of values obtained by a single investigator for a group of subjects must involve many biological and environmental factors for which there is little information. No attempt will be made to identify these factors except for the possible influence of age on the biological half-time of cesium-137 in man (age may be an indirect factor).

The data are meager, but figure 1 suggests that the value of T_b for those groups under about 20 to 25 years of age decreases with age, and that T_b may be as low as 6 to 7 days for infants a few days old. For the four infants in figure 1, the average value is about 15 days, which agrees with Pendleton's average of 19 days for five infants.

One additional feature in the data is possibly significant. For the age groups reported, no investigator (from the available reports) has reported a value of T_b greater than 70 days for *groups* under 25 years of age or a value less than about 50 to 60 days for *groups* over 25 years of age.

Guarded statements by some investigators indicate reservation in specifying trends in the data, such as relationships between T_b and age, sex, or species. Rundo has said, "If there is a change of half-life with age then it presumably starts at birth and increases steadily until adulthood is reached" (*1*). Other investigators indicate a stronger support for a relationship between T_b and age. Bengtsson *et al.* state "The results also confirm that biological half-time for cesium increases with age" (*12*). Onstead *et al.* report that in their studies involving more than 6,000 individuals, " . . . our findings suggest that, within a single species, biological half-life is dependent on age" (*17*).

In referencing the use of 100 days for the biological half-life of cesium in man, the December 1964 report to the Federal Radiation Council by the National Academy of Sciences Advisory Committee, entitled "Implications to Man of Irradiation by Internally Deposited Strontium–89, Strontium–90, and Cesium–137" (*18*) contains the following:

> "This value is almost certainly too large for children, perhaps by a factor of three to five."

The Federal Radiation Council, in its Report No. 7, (*19*) stated:

> "The data for persons younger than 25 years suggest that the biological half-life before maturity may be a function of age. Biological half-lives of about 20 days or less have been reported for infants. For this report a value of 30 days is used as the biological half-life of cesium–137 in infants."

A value of 30 days for infants appears to be a conservative assumption since the available data for infants show values close to, but below, this value.

Boni's value of 81 days, which is applicable for adults 30 to 40 years of age, is in close agreement with the average value of the lower limit for adults for all investigators of 78 days. However, there are little data for ages within the category specified as "adults" to determine if there is a trend of change in T_b as a function of age above about 25 years. The average value for adults for all investigators, those that specified a range of values and those that did not, is 101 days. The most data for an early study for all ages in a population group are for the Marshallese people, with a value of 70 days reported (*5*).

The data of Miettinen suggest an average value of about 70 days for the ages 16 through 75 years. Lists of "age limits" indicate most of these individuals were less than 50 years of age. Whether the inclusion of individuals of ages down to 16 years has the effect of lowering the average value of T_b for these groups compared to data on groups of "adults" presented by Rundo and Hansen and others, is not known. Possibly other biological and environmental factors are more important.

Model development

Considering the available values of T_b for the entire range of ages in the population, the trend that is suggested for T_b and age may be presented graphically. The solid line in figure 2 is drawn to account for the apparent rapid change of T_b with age for those less than about 25 years of age, to provide an average value of about 80 days for younger adults as suggested by Boni's measurements, and to provide an average value for adults over 25 years of age of about 100 days. Considering all age groups, the solid line in figure 2 develops an average T_b for all ages of about 75 days.

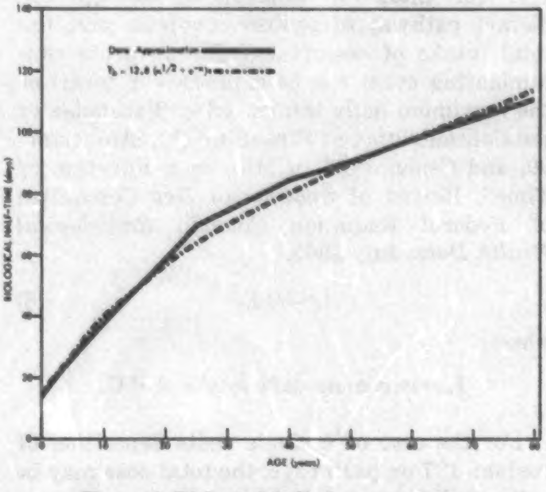

Figure 2. Biological half-time versus age

The three segments of figure 2 may be approximated by:

$$T_b = 12.8\,(x^{\frac{1}{2}} + e^{-x}) \quad (1)$$

where:

T_b = biological half life (years)
x = age (years)

The dotted curve in figure 2 shows that the fit is good for all ages. While this expression does not provide for estimating effective half-times of cesium–137 for individuals, it does provide a close approximation to averages of measured values of cesium–137 retention for groups of subjects.

Equation (1) may be combined with the equation in FRC Report No. 7 (*19*) that relates dose to whole body and bone marrow in rads to intake of cesium–137 to form a generalized expression that includes the age of various groups within an exposed population:

$$D=\frac{I_t}{W}\times 0.03\times 1.44\,[12.8\,(x^{\frac{1}{2}}+e^{-X})]$$

$$D=\frac{0.55\ I_t\ (x^{\frac{1}{2}}+e^{-X})}{W} \qquad (2)$$

where:

D = total dose (rads)
I_t = total intake of ^{137}Cs (microcuries)
W = body weight (kilograms)
x = age of exposed group (years)

This equation applies where it can be assumed that body weight, W, does not change significantly during exposure.

If the intake of concern is through the dietary pathway of pasture-cow-milk-man, the total intake of cesium–137 for an acute contaminating event can be expressed in terms of the maximum daily intake. (See "Estimates of the Concentration of Strontium–89, Strontium–90, and Cesium–137 in Milk as a Function of Time", Report of Special *Ad Hoc* Committee of Federal Radiation Council, *Radiological Health Data*, July 1965.

$$I_t \sim 32\ I_m \qquad (3)$$

where:

I_m = maximum daily intake of ^{137}Cs

For the case of a single acute deposition of cesium–137 on pasturage, the total dose may be estimated from:

$$D=\frac{17.6\ I_m\ (x^{\frac{1}{2}}+e^{-X})}{W} \qquad (4)$$

For those less than about 10 years of age, most of this dose will have been received within about 1 year.

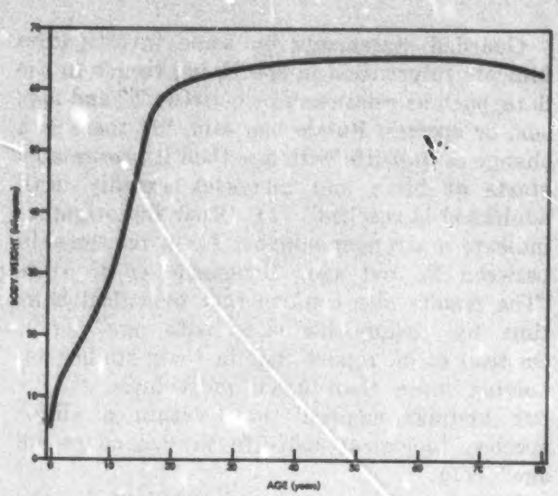

Figure 3. Body weight versus age (average for male and female)

Model application—dose estimates

Figure 3 gives the average male and female body weights in kilograms from birth to 80 years. The average values of body weight for various ages are generally not the same for male and female; however, the differences in weight are not large. For these body weights and using the generalized expression for dose, figure 4 presents the total whole body and bone marrow dose as a function of age for a total intake of 1.0 microcurie of cesium–137. The doses in figure 4 would also be obtained using equation (4) and a maximum daily cesium–137 intake in milk of $^1/_{32}$ microcurie or 31 nanocuries from an acute deposition of cesium–137.

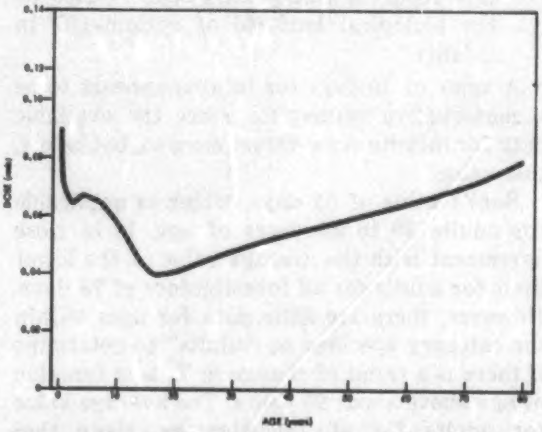

Figure 4. Total whole body and bone marrow dose from internal cesium–137 versus age (an assumed total intake of 1 μCi ^{137}Cs)

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Figure 4 indicates that with the use of this model for biological half-time, the highest and lowest doses for all ages from a given intake of cesium–137 differ by a factor of about two. This occurs even though body weights vary by a factor of about 20, and biological half-times vary by a factor of about 10. For the younger ages, those less than 1 year of age receive the highest dose. Those 70 to 80 years of age may receive a comparable dose. However, definitive data for ages greater than 50 are not available and the model suggested may not be really representative for ages over 50 years.

Again, if one assumes that the dietary item of interest is whole milk, the doses in figure 4 can be modified by a pattern of intake for milk. Table 2 presents data on average at-home milk consumption as a function of age. Values of average consumption in table 2 were developed from a percentage distribution of milk intake by age (*Radiological Health Data,* January 1963). This study of at-home milk consumption was conducted throughout the United States in July 1962. Since the study did not include consumption of whole milk outside the home, consumption may be underestimated for those ages consuming whole milk away from home. Table 2 also presents the average consumption by each age group relative to consumption by males less than 1 year of age (the intake normalization factor). The average consumption for males less than one year of age is seen to be 17.8 ounces per day. This is approximately one-half liter per day (16.9 oz/day).

Table 2. Average daily fresh whole milk consumption at home in U.S.[a]

Age (years)	Average consumption (fluid ounces)		No consumption (percent)	Normalization factor consumption/<1 year male consumption	
	Male	Female		Male	Female
<1	17.8	16.3	38.0	1.0	.92
1–4	17.8	16.9	15.9	1.0	.95
5–9	16.6	14.5	20.5	.93	.81
10–14	16.9	12.7	25.0	.95	.72
15–19	16.3	10.2	28.9	.92	.58
20–24	11.8	7.5	35.1	.66	.42
25–29	9.8	6.8	39.1	.55	.38
30–34	8.7	5.7	37.5	.49	.32
35–44	8.3	5.7	39.1	.47	.32
45–54	7.6	5.4	42.0	.43	.31
55–64	8.1	5.9	40.9	.45	.33
> 65	8.6	6.8	35.4	.48	.38

[a] Average consumption values and normalization factors developed from report on "National Food Consumption Survey" in Radiological Health Data, Vol IV, No. 1, January 1963.

The doses in figure 4, averaged for each age group, have been modified by the normalization factors in table 2 to illustrate the effects that a pattern of milk consumption may have on dose. The results are shown in figure 5.

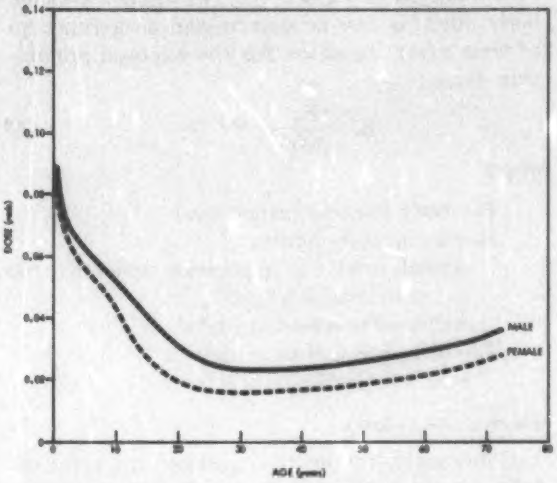

Figure 5. Total whole body and bone marrow dose from internal cesium–137 versus age (an assumed pattern of dietary intake of cesium–137 in milk for males less than 1 year of age consuming 1 μCi)

The influence of the pattern of milk consumption in table 2 is to reduce the average doses for most ages relative to the doses in figure 4.

The sex-related differences in milk consumption cause males to receive higher average doses than females for all ages. The difference in dose between ages receiving the highest and lowest values is a factor of about four for male and about five for female, and males less than 1 year of age receive the highest dose.

The yearly dose that would be received by various age *groups* from a continuing daily intake of cesium–137 may be estimated by determining the average cesium–137 body burden during the year and using the following:

$$D_r = \frac{B/W}{85.7} \qquad (5)$$

where:

D_r = dose rate (rads per year)
B = average body burden (nanocuries)
and W = body weight (kilograms)

The determination of average body burden for a continuing intake of cesium–137 is described in the following section (see equation (9) and figure 7).

Model application—body burden estimates

For acute ingestion of cesium-137 (ingestion over a period of a few days), estimated average body burdens can be determined as a function of time after ingestion for the exposed population from:

$$B_t = \frac{B_o}{1000} e^{-.693\,t/T_b} \qquad (6)$$

where

B_t = body burdens (nanocuries)
B_o = initial body burden,
= total intake in picocuries assuming 100 percent absorption,
t = time after ingestion (days),
T_b = biological half-time (days),
$= 12.8\ (x^{\frac{1}{2}} + e^{-x})$

where x age (years).

Conversely, for acute ingestion, the total intake can be estimated for various age groups if their average body burdens are known at some time after ingestion.

For ingestion of cesium-137 that decreases with time, average body burdens within the population may be estimated as a function of time from:

$$B_t = \frac{R_o}{1000\,(\lambda_i - \lambda_b)}\ (e^{-\lambda_b t} - e^{-\lambda_i t}) \qquad (7)$$

where

R_o = initial rate of intake (picocuries per day),
λ_b = biological decay constant
$= .693/12.8(x^{\frac{1}{2}} + e^{-x})$,
λ_i = intake decay constant $= .693/T_i$,
T_i = half-time for intake after maximum concentration (days)

FRC Report No. 7 (*19*) indicates that for an acute deposition on pasturage, the total cesium-137 intake from milk may be 32 times the intake on the day of the maximum concentration in milk (assuming the same amount of milk is consumed each day). The portion of the total intake occurring prior to maximum concentration is about 16 percent of the total intake. The intake occurring after maximum concentration is about 27 times the maximum. Therefore, 27 days may be considered the mean time of cesium-137 in milk following maximum concentration. The half-time for intake after maximum concentration is:

$$T_i = 27 \times 0.693 \sim 18 \text{ days.}$$

For acute deposition of cesium-137 on pasturage utilized by dairy cows, it has been estimated that the maximum concentration in milk will occur about 6 days following deposition. The average body burden for various ages resulting from such changing levels in milk may be approximated by:

1. Assuming total milk intake prior to maximum concentration is an acute intake using equation (6).
2. Assuming an additional intake using the maximum daily intake as R_o in equation (7).

The estimated body burden from milk consumption will be the burden from equation (6), plus the burden from equation (7). Contributions to total body burden from other contaminated foods will be additive. Figure 6 presents the body burden for males 1 year of age, for an acute deposition on pasturage, where the maximum concentration of cesium-137 in milk reached a level of 2,000 pCi/liter. Figure 6 indicates that maximum burden will be reached in about 25 days for this age group.

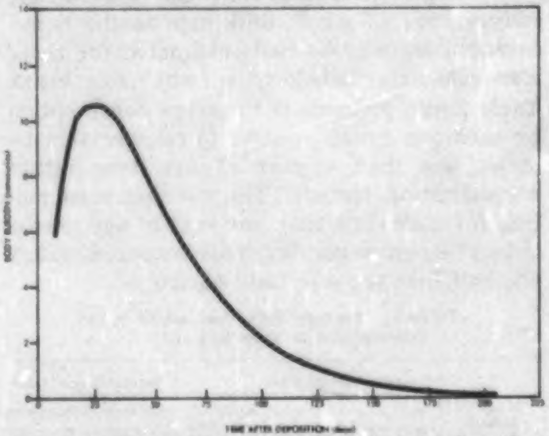

Figure 6. Cesium-137 body burden for males less than 1 year of age versus time after acute deposition (assuming maximum milk concentration reaches 2,000 pCi/liter)

Other assumptions regarding the pattern of milk consumption versus age may apply for various portions of the U.S. population. Body burdens for the milk consumption pattern in table 1 may be underestimated for the ages consuming quantities of milk away from home.

For a continuing intake of cesium-137 (intake that occurs over a period of years), estimates of average body burdens within a population can be developed from the following:

195

$$B = R\ T_m\ A_f/1000 \qquad (8)$$

where:

B = body burden (nanocuries)

R = rate of intake of ^{137}Cs (picocuries per day)

T_m = biological mean time (days),

A_f = absorption factor, assumed to be 1.0.

With biological mean time expressed as a function of age, equation (8) becomes:

$$B = 0.018\ R\ (x^{\frac{1}{2}} + e^{-x}) \qquad (9)$$

where:

x = age (years)

Equation (9) may be used, for example, to estimate the average body burdens of cesium-137 in the U.S. population from milk consumption. The U.S. Public Health Service pasteurized milk network results for 1963 and 1964 averaged 114 and 109 pCi/liter, respectively (*20, 21*).

These data indicate that the average level of cesium-137 in U.S. milk supplies has decreased slowly over the past 2 years. Considering the small change in these levels, it can be assumed that the various age groups in the population are in equilibrium with the cesium-137 levels in milk they consume for the portion of their body burden due to milk intake, and their average body burdens for 1964 may be determined from an average value of daily cesium-137 intake.

If it is assumed that milk ingestion for males less than 1 year of age resulted in an average intake of 55 pCi/day during 1964, and using the normalization factors in table 2 to estimate milk consumption by other age groups in the population, estimated body burdens may be determined from equation (9). The resulting values are shown in figure 7.

The dose to males less than 1 year of age from at-home milk consumption, using equation (5), is about 0.002 rad or 2.0 millirads in 1964. The point should be stressed that these estimates apply only to that portion of the cesium-137 body burdens of the U.S. population due to milk consumption at home. The contribution to body burden and whole body dose from milk consumption outside the home and from other items of the diet are additive.

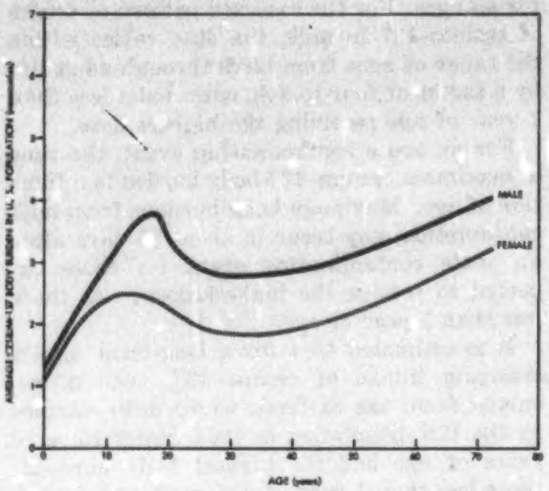

Figure 7. Estimated cesium-137 body burdens from milk consumption for U.S. population in 1964

For cesium-137 in U.S. milk supplies, estimates of cesium-137 body burden in figure 7 indicate that males 15 to 20 years of age had the highest levels; those less than 1 year of age, male and female, had the lowest levels; and females of all ages had a lower average level than males of the same age.

Summary

The observations of biological half-time for cesium-137 in man indicate that half-time is a function of age. The average biological half-times for cesium-137 from birth through adult life vary by a factor of about 10. A simple mathematical expression has been presented which relates half-time of retention of cesium-137 and age. Though the model is crude, it has utility in predictions of doses and body burdens from cesium-137 for various ages within an exposed population. Additional measurements of cesium-137 retention are needed, particularly for younger age groups, to further refine the model and to improve prediction capability. More data are also needed for the elderly.

The combination of changes in half-time and body weight results in a dose variation, for a given cesium-137 intake, from birth through adult life, of a factor of about two. The addition of assumptions regarding patterns of milk intake as a function of age and resultant cesium-137 intake leads to a different distribution of dose with age than is found for a fixed intake for all ages. For the assumed pattern of intake of cesium–137 in milk, the dose varies within the range of ages from birth through adult life by a factor of four to five, with males less than 1 year of age receiving the highest dose.

For an acute contaminating event, the time of maximum cesium–137 body burden is a function of age. Maximum body burdens from milk consumption may occur in about 25 days after an acute contaminating event for those expected to receive the highest dose; *i.e.*, those less than 1 year of age.

It is estimated that for a long-term, slowly changing intake of cesium–137, such as occurred from use of fresh whole milk supplies by the U.S. population in 1964, males 15 to 20 years of age had the highest body burdens; those less than 1 year of age, male and female, had the lowest body burdens; and females of all ages had lower body burdens than males of the same age.

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THE RELATION BETWEEN CESIUM-137 IN MAN AND HIS DIET IN THE CHICAGO AREA [1]

Philip F. Gustafson [2]

Because of the relatively short biological half-life of cesium–137 in man (approximately 100 days for adults), changes in the cesium–137 content of the diet lead fairly rapidly to corresponding changes in the human burden of cesium–137. As a consequence, equilibrium or near-equilibrium between diet and body burden (*i.e.*, daily cesium–137 intake = daily cesium–137 elimination) can be attained within a few months. Variations in the rate and intensity of nuclear testing produce changes in the deposition of cesium–137 and its uptake by plants, which in turn cause the cesium–137 body burden of man to vary correspondingly. A period of maximal concentration of cesium-137 in foods should be followed relatively soon by maximal body burdens of this radionuclide. This is in contrast to strontium–90, the long biological half-life of which does not permit maximum concentrations in the body to be reached for a considerable time after maximum levels appear in the diet.

The relation between the cesium–137 content of the Chicago diet and the body burdens of cesium–137 in a number of Argonne employees has been examined in the hope of providing a reliable means of predicting future levels in man, as well as to gain insight into the more fundamental question of cesium metabolism itself. Analyses of the cesium–137 content of the various foods in the Chicago portion of the Tri-City Diet Study (*1*) have been made by gamma-ray spectrometry since April 1961. For the present purposes, the entire diet has been divided into five major categories: milk, meat, grain products, fruits, and vegetables. A few items, such as eggs and rice, have been omitted from the present consideration either because of the small amounts consumed or their low cesium–137 content. Fish has been excluded because of the relatively small amounts consumed and the extreme variability caused by the presence or absence of freshwater varieties which contain relatively high concentrations of cesium–137 (*2*).

The daily intake of cesium–137, in pCi/day, coming from each of the five diet categories during each quarter extending from April 1961 through July 1965 is shown in figure 1. In general, milk, meat, and grain products provided most of the cesium–137 intake. Maximum levels in the five categories, and hence in the total intake, were reached in late 1963 and early 1964, and have diminished rather consistently since that time. Also indicated in figure 1 is an attempt to extrapolate future levels on the basis of trends observed through July 1965. These extrapolated levels will be used subsequently to determine total daily intake and resultant body burdens.

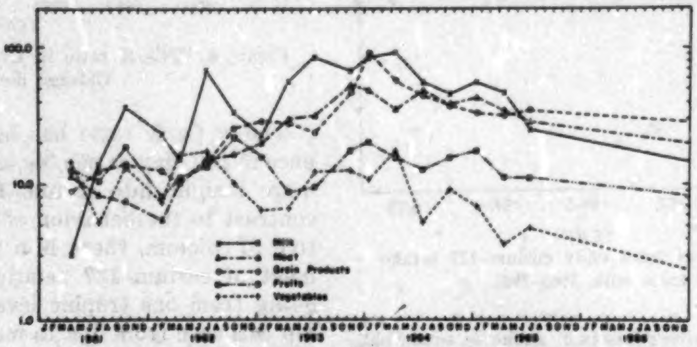

Figure 1. Daily cesium–137 intake (pCi/day) derived from five food categories

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[1] Taken from HASL–164:301–311 (October 1, 1965). This work was supported by the U.S. Atomic Energy Commission.

[2] Dr. Gustafson is an associate physicist with the Division of Biological and Medical Research, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60440.

The percentage of cesium-137 in the total diet derived from milk is illustrated in figure 2. The supposition is often made that milk contributes on the order of 60 percent of the daily cesium-137 intake. The data in figure 2 indicate 35 to 40 percent of the total daily intake in the Chicago area comes from milk, and further suggest that the current importance of milk relative to the total diet cesium-137 is decreasing. All five categories show primary dependence upon the rate of cesium-137 deposition, rather than upon total accumulation of the radionuclide on the ground. This is inferred from the observed decrease in cesium-137 concentration in foods from 1964 through the present, even though present levels in soil are as high as, if not higher than, those in 1963. Fresh milk, fruits, and vegetables show this most clearly even though inclusion of canned and frozen items increases the time between production and consumption. The fact that cesium-137 concentration in grain products appears to be decreasing more slowly may reflect the effect of storage of this commodity, as grain grown in 1963 may not reach the consumer until 1965. Considerable grain is used for animal feed, and as such constitutes an important source of cesium-137 in beef and pork, the cesium-137 contents of which may also diminish more slowly. The effect of grain storage for unknown periods of time creates an uncertainty in the prediction of future diet levels in man by extrapolation of current observations.

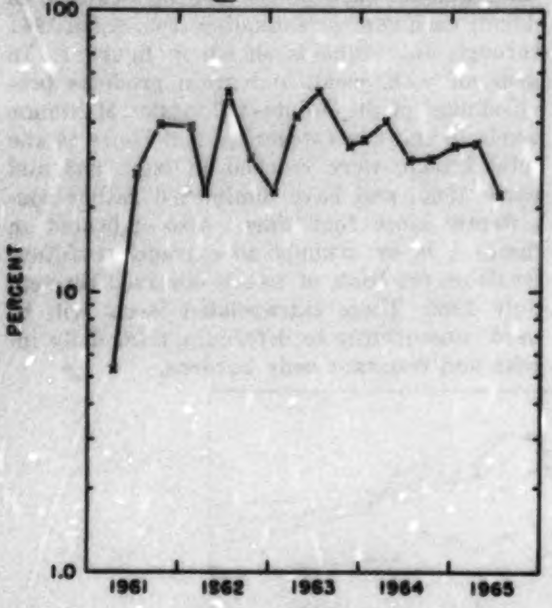

Figure 2. Percent of total daily cesium-137 intake derived from milk, 1961-1965

The daily intake of cesium-137, expressed in pCi ^{137}Cs/g K, determined from April 1961 through July 1965, is shown in figure 3. Values extending beyond July 1965, also plotted in figure 3, were obtained from extrapolation of the data in figure 1. The potassium value used in deriving these ratios was 4.5 g/day contained in 1.85 kg of food. A figure of 4.5 ± 0.3g potassium/day was the average found during 1962 through 1964.[3] The average ^{137}Cs/K ratios in man (*in vivo* ratios) observed during this time by Miller are also shown in figure 3 (*5, 6*).

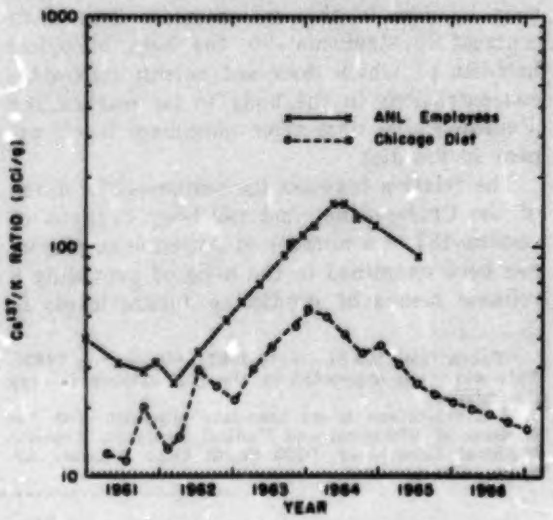

Figure 3. ^{137}Cs/K ratio in Chicago residents and Chicago diet

The ^{137}Cs/K ratio has been used in preference to pCi/day or pCi/kg as it appears to yield more insight into cesium-137 metabolism. In contrast to the behavior of strontium-90 relative to calcium, there is a pronounced enrichment of cesium-137 relative to potassium in going from one trophic level to a higher level (in this case from diet to man). This phenomenon has been discussed by Pendleton *et al.* (*7*), who postulate that the increase in ^{137}Cs/K ratio is essentially the ratio of the biological half-time of cesium–137 to that of potassium in the animal in question. The diet ratio and *in vivo* ratio curves shown in figure 3 have similar shapes; however, the diet ratio reached a maximum approximately 4 months earlier than the *in vivo* ratio. The excursions in the values of the diet ratio seen during late 1961 and through most of 1962 are doubtless due to the presence of fresh cesium–137 coming into the food supply. This contamination may vary not only in time, but also in distribution throughout a given food item such as milk. In any event, the *in vivo* ratio does not clearly show these variations, but tends to smooth them out in the increasing trend of the ^{137}Cs/K ratio in man during this time.

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[3] This value of daily potassium intake is somewhat higher than that of 3.0 ± 0.3 g/day found by other investigators, and may reflect actual differences in diet composition (*3, 4*).

In figure 4, the diet ratio data have been transformed to coincide, as far as possible, with the *in vivo* ratios. This transformation was accomplished by increasing the diet ratio by a factor of 3.0 and by moving the entire diet ratio curve forward in time by 4 months, so that the maximum would coincide with that of the *in vivo* ratio. This transformation results in a good fit between the diet and *in vivo* ratios from mid–1963 through mid–1965. The factor of 3.0 increase applied to the diet ratio is in accord with the hypothesis of Pendleton *et al.* (*7*), as regards the ratio of cesium–137 to potassium biological half-lives in man. A similar increase ratio was noted by McNeill and Trojan (*4*) during a limited time interval in 1959. Morgan and Arkell observed a threefold increase in the ^{137}Cs/K ratio between urine and whole-body measurements in early 1961 (*8*). The overestimation of the *in vivo* ratio by this transformation during much of 1962 and early 1963 is probably due in part to the nonhomogeneous contamination of the diet discussed earlier. It is also true that the transients in the diet ratio were of short duration, and equilibrium between diet and man was not possible under such circumstances.

Future values of the *in vivo* ^{137}Cs/K ratio may be found either from extrapolation of the transformed diet ratio or direct measurement of the *in vivo* ratio curves in figure 4. According to this approach, the *in vivo* ratio in the Chicago population should vary from 70 pCi ^{137}Cs/g K in early 1966 to 50 pCi ^{137}Cs/g K by the end of the year. At present the effective half-life of cesium–137 in human adults in this area—under conditions of continuous cesium–137 ingestion varying as indicated in figures 1 and 3—is 2½ years. The essential agreement at this time between these two sets of independent data places the prediction of cesium–137 body burdens over the next year or two on a rather firm foundation.

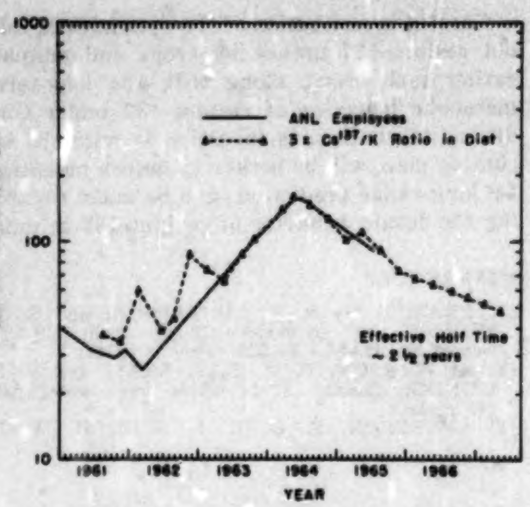

Figure 4. Comparison of human and modified dietary ^{137}Cs/K ratios

The ability to make longer range predictions, however, must await more precise knowledge in at least three areas: (1) the temporal changes in the cesium–137 content of the diet caused by storage or other delay mechanisms in the flow of foodstuffs from production to consumption; (2) the relative importance of accumulated cesium–137 deposition and fresh deposition after many years time; and (3) examination of the possibility that a portion of the total body cesium–137 burden is actually present in bone, and consequently may have a relatively long (>>100 days) biological half-time. This would cause the body burden to decrease more slowly than anticipated on the basis of diet information alone. Preliminary work done at this laboratory in 1961 indicated that as much as 10 percent of the total body cesium–137 might have resided in bone during 1961 prior to the resumption of nuclear tests (*9*).

Careful investigation of the dynamics of fallout cesium–137 uptake by crops and animals eating such crops, along with the long-term metabolic behavior of cesium–137 under conditions of continuous ingestion in animals, including man, will be necessary before meaningful long-range predictions can be made regarding the future behavior of cesium–137 in man.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in RHD since November 1960. Summaries follow for the Brookhaven National Laboratory and the Rocky Flats Plant.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentrations limits, are applicable to effluents released from AEC installations.

1. Brookhaven National Laboratory January–June 1965

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by discharge of coolant air from the graphite research reactor, (2) by radiation from an ecology forest gamma source, and (3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

Area monitoring

The radioactivity in the discharge coolant air is almost entirely due to argon–41, a beta-gamma emitter. Because exposure to argon–41 is due to external gamma, the monitoring is performed by measuring the exposure rate in milliroentgens per week (mR/wk) rather than the concentration in air.

Late in 1961 a 10,000–curie cesium–137 gamma source was installed in the ecology forest about 800 meters equidistant from the north and east boundaries (*1*).

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[1] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

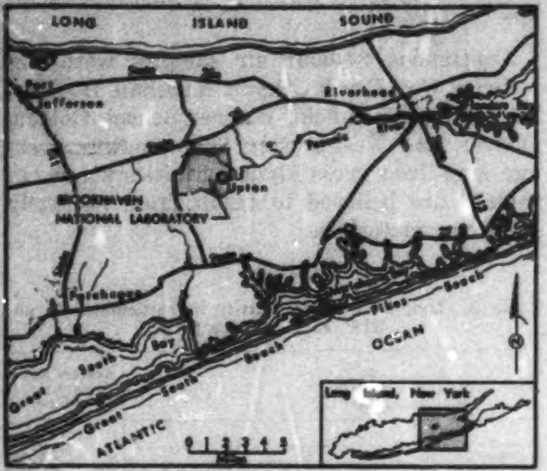

LONG ISLAND SOUND
Port Jefferson
Riverhead
BROOKHAVEN NATIONAL LABORATORY
Upton
Patchogue
Great South Bay
Fire Island
OCEAN
ATLANTIC
Great South Beach
Long Island, New York

Figure 1. **Brookhaven National Laboratory and surrounding area**

Table 1 presents the average external gamma exposure rates measured at the four stations shown in figure 2. The higher levels of the Northeast perimeter station are primarily due to the ecology forest source. The environmental maximum permissible dose recommended by the Federal Radiation Council is 0.5 rem/yr (10 mrem/wk) above the natural background, averaged over a 1-year period.

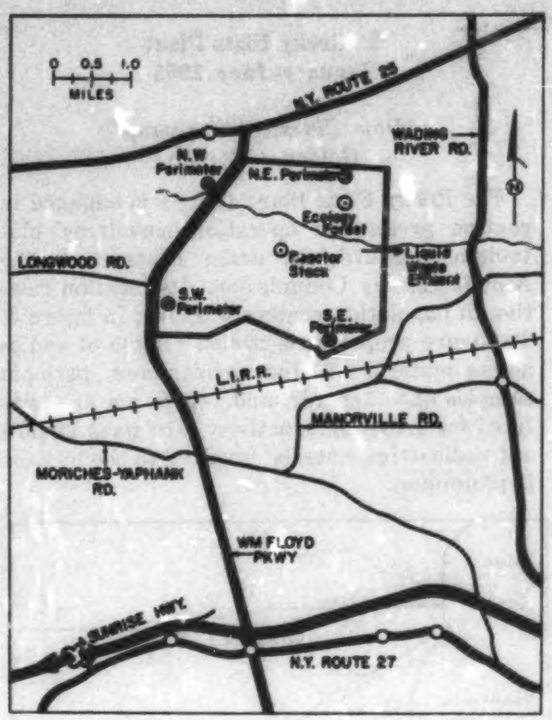
Table 1. External gamma levels at BNL site boundary, January–June 1965

(Average exposure rates in mR/wk)

Period	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast perimeter
Gamma exposure from laboratory operations:				
First half 1965	0.23	0.13	0.61	2.27
January	0.10	0.15	0.74	1.78
February	0.34	0.08	0.55	1.74
March	0.05	0.17	1.02	1.52
April	0.35	0.15	0.86	1.84
May	0.48	0.15	0.14	3.03
June	0.04	0.08	0.26	3.78
Average undisturbed background	2.10	2.11	2.45	2.35

Water monitoring

The BNL liquid waste effluent is monitored for gross beta concentrations at the site boundary. Table 2 presents the average concentration together with the total activity released as determined by using known effluent flow rates.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MILES
N.Y. ROUTE 25
WADING RIVER RD.
N.W. Perimeter
N.E. Perimeter
Ecology Forest
Reactor Stack
Liquid Waste Effluent
LONGWOOD RD.
S.W. Perimeter
S.E. Perimeter
L.I.R.R.
MANORVILLE RD.
MORICHES-YAPHANK RD.
WM FLOYD PKWY
SUNRISE HWY.
N.Y. ROUTE 27

Figure 2. Brookhaven National Laboratory monitoring station locations

Table 2. Gross beta acivity in BNL liquid waste effluent, January–June 1965

Period	Average beta concentration (pCi/liter)	Total beta activity discharged (mCi)
First half 1965	41	22.4
January	37	2.8
February	46	4.5
March	62	4.6
April	41	3.4
May	35	3.3
June	31	3.8

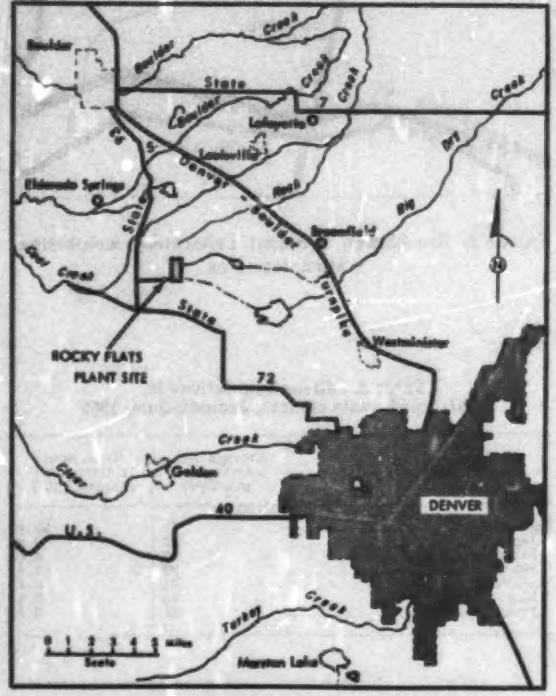
Recent coverage in *Radiological Health Data:*

Period	**Issue**
Third and fourth quarters 1961	*June 1962*
First and second quarters 1962	*January 1963*
July 1962 to June 1963	*February 1964*
July 1963 to June 1964	*December 1964*
July–December 1964	*June 1965*

2. Rocky Flats Plant
January–June 1965

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To assure properly controlled release of radioactive materials to the environment, periodic samples of water, air, and vegetation are analyzed for gross alpha activity. The most abundant radioactive material involved in the process is plutonium.


Boulder
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Denver
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Eldorado Springs
State
Rock
Dry
Big
Broomfield
Coal
Creek
State
Westminster
ROCKY FLATS
PLANT SITE
72
Creek
Clear
Golden
DENVER
40
U.S.
Turkey
Creek
Marston Lake
0 1 2 3 4 5 Miles
Scale
N

Figure 3. Location of the Rocky Flats Plant environment, Denver, Colorado

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized Front Range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Continuous 24-hour air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha activities shown in table 3 are believed to result from naturally occurring materials.

Table 3. Long-lived alpha activity in particulates in air, RFP, January–June 1965

Period	Average alpha concentration (pCi/m³)
January	<0.006
February	<0.006
March	<0.006
April	<0.006
May	<0.006
June	<0.006

Water

Non-routine raw surface water samples were collected from a number of outlying streams and lakes along with the vegetation samples. Results of alpha activity analyses are given in table 4. Stream and vegetation samples will be reported later.

Table 4. Alpha activity in water collected from reservoirs in the vicinity of RFP, January–June, 1965

Reservoir	Average alpha activity (pCi/liter)
Great Western	2.1
Standley	2.5
Baseline	2.5
Ralston	2.2

Recent coverage in *Radiological Health Data:*

Period	Issue
July 1962–June 1963	*February 1964*
July 1963–June 1964	*December 1964*
July–December 1964	*June 1965*

REFERENCE

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REPORTED NUCLEAR DETONATIONS, NOVEMBER 1965

During November 1965, one United States nuclear test was announced by the Atomic Energy Commission. This was a low-yield test (less than 20 kilotons of TNT equivalent) conducted underground at the Commission's Nevada Test Site on November 12, 1965.

The Commission also announced that seismic signals were recorded from the Soviet nuclear testing area in the Semipalatinsk region on November 21, 1965. The signals indicated the equivalent of a low to low-intermediate yield range (low-intermediate is 20–200 tons of TNT equivalent).

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    Pan America
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